THE STANDARD CYCLOPEDIA OF MODERN AGRICULTURE AND RURAL ECONOMY

BY THE MOST DISTINGUISHED AUTHORITIES AND SPECIALISTS UNDER THE EDITORSHIP OF

PROFESSOR R. PATRICK WRIGHT

F.H.A.S. F.R.S.E. PRINCIPAL OF THE WEST OF SCOTLAND AGRICULTURAL COLLEGE GLASGOW

VOLUME V

DUC—FIR

THE GRESHAM PUBLISHING COMPANY

34 AND 35 SOUTHAMPTON STREET STRAND LONDON

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VOLUME V

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The classic series of articles on insects by the late John Curtis have been embodied in the work, revised by Professor F. V. Theobald and Mr. Cecil Warburton, M.A., and bear the initials of J. C. and F. V. T. or C. W.

In like manner the great botanical articles of the late Professor John Lindley, which, like Curtis's articles above mentioned, were contributed to Morton's *Cyclopedia of Agriculture*, have, under Professor A. N. M'Alpine's revision, been embodied over the initials J. L. and A. N. M'A.

FEMALE—DEVELOPMENT—THE FUNCTIONAL INDEPENDENCE OF THE UNITS OF THE BODY—VARIABILITY—INHERITANCE—REVERSION. SECOND PART:—STATEMENT OF THE HYPOTHESIS—HOW FAR THE NECESSARY ASSUMPTIONS ARE IMPROBABLE—EXPLANATION BY AID OF THE HYPOTHESIS OF THE SEVERAL CLASSES OF FACTS SPECIFIED IN THE FIRST PART—CONCLUSION .. .. Pages 349–399

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DOMESTICATION—NATURE AND CAUSES OF VARIABILITY—SELECTION—DIVERGENCE AND DISTINCTNESS OF CHARACTER—EXTINCTION OF RACES—CIRCUMSTANCES FAVOURABLE TO SELECTION BY MAN—ANTIQUITY OF CERTAIN RACES—THE QUESTION WHETHER EACH PARTICULAR VARIATION HAS BEEN SPECIALLY PREORDAINED. 400–428

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ERRATA TO VOL. II.

Page 14, four lines from bottom: *for* "*A. moschata*, Linn.," *read* "Cairina moschata."
„ 134, last line: *for* "*apera*," *read* "aperea."

THE STANDARD CYCLOPEDIA OF MODERN AGRICULTURE

Ducks, Breeds of.—From the earliest ages of the Christian era, ducks have been domesticated in Europe, and probably long before that period in Asia. Columella in the first century A.D. described how this was done, namely, by taking eggs from the wild ducks' nests and hatching by means of hens. This was probably the method adopted everywhere. It is generally admitted that all our domesticated ducks, in spite of the remarkable variations to be found in them, are descended from the Mallard, or Wild Duck, which is found throughout *Europe, Asia, and North America*. The breed which most resembles the parent stock is the Rouen (see ROUEN DUCK), except in size of body. Such variations as are to be found among domesticated ducks are due to those changes which take place when brought into the service of man, fixed and perpetuated by his selection. Some of our most prominent breeds have been produced in Europe and others in Asia, where duck breeding is carried on extensively, more especially in China.

Several races of ducks are described separately (see AYLESBURY DUCK, MUSCOVY DUCK, PEKIN DUCK, ROUEN DUCK, &c.), but there are others which may be briefly mentioned here.

Blue Swedish, a very useful duck of medium size (5½ to 8 lb.). The body colour is steel blue-grey, with a white cravat and throat. They are average layers, and fatten well, producing excellent quantity and quality of flesh. They are met with to a considerable extent in North Germany and Scandinavia.

Blue Termonde is found in Belgium, where it is largely bred, and probably has the same origin as that named above. The plumage is slate-grey, but the white cravat and throat are not so general as in the Swedish. They are somewhat longer in body, and are about 2 lb. heavier. The flesh is abundant but somewhat hard. They are good layers, and very vigorous in constitution.

Cayuga, a smallish duck, with metallic-black plumage and black legs. They are fair layers and very good in flesh, which is abundant on the breast and of fine quality, but in this country they have been chiefly bred for exhibition purposes. The origin is American.

Duclair-Rouen is supposed to be descended from an old Normandy duck, and is very similar to the Rouen except in plumage, which is particoloured, in that the neck and breast are white. They are largely bred in the lower Seine valley in France, where they are claimed as very profitable, in that they are quick growers and abundant in flesh qualities. Size medium.

Huttegem, a hardy variety of duck bred in Belgium, where they meet a demand for early ducklings, as they can withstand the severe winter conditions in the Oudenarde district. They are supposed to be descended from the Blue Termonde and the Indian Runner. They are medium in size, good layers, grow rapidly, and fatten well. The colours are uneven, but a white chest and throat is common to all.

Indian Runner is a comparatively modern breed which has attained considerable popularity as layers, but they are being bred for exhibition on lines which is practically ruining them for utility. The name is derived from the long bottle-shaped body and the manner of stretching forward the neck when walking. They are excellent in flesh but small in size, not exceeding 4½ lb.

Merchtem is a white duck found in Belgium, pure-white in plumage and very similar to the Aylesbury, except that it is reddish in the bill and longer in the leg. In size the ducks are medium, very quick growers, and are chiefly bred to meet the demand for early ducklings.

There are many other races, but they are purely ornamental, some being very beautiful.

[E. B.]

Duckweed (Lemna) is the name applied to minute floating water plants of the monocotyledon class. The body is not a green thread as in many of the freshwater Algæ, but a flat green disk, from the lower surface of which a simple root with a well-marked root cap hangs down into the water. The green disk propagates rapidly and extensively by producing lateral outgrowths on its sides, which become new disks, capable of detaching. By repeated propagation in this way the surface of a standing pool is soon covered over as with a green mantle. Duckweed also produces flowers and seeds, but so minute and concealed that they are difficult to find. Four species occur in Britain, and the most common of these is Lesser Duckweed (*Lemna minor*).

[A. N. M'A.]

Du Mans Fowl.—The breed here named is only met with in one district of France. It is closely allied to another race of greater importance (see LA FLÈCHE FOWL), which is produced in greater numbers in the valley of La Sarthe. Both are entirely black in plumage.

The chief differences are that the Du Mans has a rose comb, and that it is a little slighter in build of body. They are only moderate layers, but produce fleshy birds with an abundance of white, delicate meat, and fatten extremely well. They are fine in bone, and hardy on suitable soils. [E. B.]

Dun. See Colour in Animals.

Dun-bar Moth. See Cosmia.

Dunes.—This term, from the old Celtic *dun*, is now reserved for the hills known as *sand dunes*, formed by sand blown in along the coasts. Where the space on a sandy shore between high- and low-tide marks is considerable, and where winds blow frequently from the sea, the sand is carried persistently inwards, forming typical sandhills and encroaching on the lands beyond. [G. A. J. C.]

Dunes, Planting of.—Dunes have been largely planted with timber crops in France and Germany, but the chief such plantation in Britain is on the Holkham sandhills in Norfolk. By far the largest work of this sort is the planting of the barren Landes of Gascony, where the outer dune extends for 190 miles, and where about 160,000 ac. of sandy waste have (chiefly since 1851) been fixed and planted with Maritime Pine at an average cost of between £7 and £8 an acre, which are now partly mature and undergoing natural regeneration. About 60 to 90 yards back from high-tide level, board palings or loosely woven hurdles of brushwood and twigs were first erected at right angles to the prevailing wind, and from 100 to 200 ft. apart, in order to prevent further drifting when once the wind-blown sand settled. Each time when this catchment fence (about 3½ ft. high) was almost buried by the sand collected, it was raised, until the outer dune was about 35 to 40 ft. above high-tide level. Then the surface was planted with Sea-marram or Bent (*Psamma arenaria*), and constant supervision was given to repair promptly any damage caused by wind or waves. Behind this outer dune the sand was fixed by sowing Maritime Pine seed (slightly mixed with Furze, Broom, and Sea-marram seed) and covering it with brushwood (preferably Furze) to protect the seedlings against blown sand, the brushwood itself being kept in place by a good shovelful of sand. The first sowings were made close under the lee of the outer dune, and were then in successive years extended inwards, each newly sown part having to windward the shelter of the older parts, and also on the landward side the protection of hurdles placed to prevent drifting sand being blown back by land winds. In Germany, save only where an outer dune has to be artificially formed for fixing the sand, hurdles are now little used, the preference being given to partial covering with turf laid in hollow 40-in. squares and with a 6-in. central piece, or else with brushwood, coarse grass, and seaweed laid down during wet weather to keep the sand damp. Pines (Scots and Banks') are then planted at 3 ft. apart, either with balls of earth or with naked roots 5 to 7 in. long, sea-coast dunes being, however, previously fixed by sowing or planting sand-grasses (*Arundo arenaria*, *Elymus arenarius*, and *Carex arenaria* chiefly). Turfing costs about 20*s.* to 30*s.*, and planting from 16*s.* to 21*s.* an acre, and the whole operation usually comes to from 40*s.* to 50*s.* an acre. In North Germany, instead of being planted, barren sandhills are sometimes sown with Everlasting Pea (*Lathyrus sylvestris*), which is there said to provide good grazing for sheep, and to be more profitable than planting Pine.

The extensive planting carried out by the Earl of Leicester on the Holkham sandhills began in 1850. Until then, these hills, about 3½ miles long and varying up to about 550 yd. wide, were merely rabbit warrens. The sand was fixed by planting and encouraging the Sea-marram (*Psamma arenaria*) and the Lyme Grass (*Elymus arenarius*) common there, and then small experiments were made in planting Austrian, Corsican, and Scots Pine, and fencing them against rabbits. During the first year the plants only grew from 1 to 2 in., but they did better in the second year, and it was then determined to exterminate the rabbits and plant the whole area. By 1865 the planting of the east end of the hills, nearly 2 miles long, was completed; and these are now thriving ornamental woods, giving good shelter to adjoining pasture lands. And since 1877 the crests of the hills have also been planted, chiefly with Austrian and Corsican Pine. Since 1882 the plantations have been considerably extended with Pines mixed in the following proportions: Corsican, 50 per cent, planted 8 yd. apart; Austrian, 25 per cent; Scots, 20 per cent; and Maritime, 5 per cent., planted at from 5 to 7 yd. apart. As these plantations are intended to be more for ornament and shelter than for timber production, these wide distances were meant to allow plenty of room for lateral extension. The higher and more exposed situations are chiefly planted with Austrian and Maritime Pine, and of course, being more exposed to storm blasts, these species do not grow so vigorously as the Corsican and Scots planted in the more sheltered parts. [J. N.]

Dung. See Farmyard Manure.

Dungstead.—As the barn is the centre of the commissariat department of the modern homestead, so is the dungstead the centre of the cleansing department. On that account it ought to be placed in as central a position with regard to byres and stable as happens to be practicable, so that only the minimum amount of labour may be spent in wheeling the waste matter peculiar to these houses thereto. And it ought to be so placed that the liquid matter that drains from these places can gravitate thereto. Moreover care should be taken that it is completely protected from the entrance of rainwater. There should, we need hardly point out, be two systems of drainage at the homestead — one to lead away the rainwater from the roofs and what falls upon the courtyards, the other to collect the dribblings from byres, pig houses, and stable, and lead them direct to the dungstead. But the two must be separate. The object in view with the one is to carry the rainwater clear of the steading, with the other to gather and concentrate at the midden all fluid manurial matters emanating from the stock

houses that might otherwise go largely to waste. The dungstead is incomplete without a liquid-manure tank (see art. under that head) annexed to it. The matter contributed by the drains referred to can either be delivered directly therein or be made to discharge into the dungstead, to find its way in thereafter with the general seepage from the accumulating dung. It is necessary, of course, that the dungstead be walled in, else the contents cannot be properly held together. The most convenient arrangement is one whereby it is practicable to tip in the dung from the level along one side or end. In some cases it is requisite to render the bottom or floor of the dungstead watertight. This can be done with rough concrete. As a rule, however, the subsoil is sufficiently retentive to prevent matter from sinking out of reach. On the other hand, one has to guard against water rising from below. Of course, if water rises through the floor, liquid manure will escape as the water subsides. The floor should be hollowed out in such a way that there will be no oozing of matter from the gateway or cart entrance to the dungstead. The liquid should all be given the tendency to gravitate in the direction of the tank. Care must be taken, however, in doing this, not to throw too much weight against the side or end wall which the tank adjoins. A little judicious banking (see EMBANKMENT) or filling up at the base of the wall will obviate this. The walls of the dungstead need to be strong and closely packed to be able to resist the thrust of the dung when heaped against them, and to prevent seepage through the joints. Concrete comes in as well adapted for this purpose. The covering of the dungstead with a roof is the simplest and most effective means of preserving the manure from waste, that is liable to be very great in a wet climate. When dungstead and foldyard are one, and cattle and pigs have the run of it, a roof is a usual accompaniment. [R. H.]

Dunlop Cheese. — Dunlop cheese is a variety with a splendid reputation in most of the industrial centres in Scotland. It takes its name from the parish and village of Dunlop, in the county of Ayr, where it has been exclusively made for more than a century.

Dunlop is a whole-milk cheese, and consequently no fat is extracted from the milk which is intended for its making.

Original Method.—The evening's and morning's milk were treated together. The evening's was either set wholly in shallow pans, or partly in pans and partly in the cheese tub or vat, a circular wooden tub in which the milk was coagulated. In the morning the two milkings were all collected in this vat and heated to 90° or 92° F. The heating was accomplished either by adding a little boiling water directly to the milk, or by warming the milk in a clean boiler. After heating, the milk was immediately renneted, often about 6.30 a.m.; sufficient home-made rennet being added to coagulate the milk in about twenty to twenty-five minutes. The coagulum was broken up near the surface by a flat-shaped perforated 'skimmer', the arms inserted very gently, and the curd broken to the bottom of the vat in this way. As soon as some of the whey had separated out from the curd and could be collected on the surface, it was ladled out of the vat. Alternate stirring and removal of whey was continued until the curd could be consolidated in the bottom of the vat. The vat was then tilted to one side, and the whey allowed to drain away from the curd continuously. To facilitate draining at this stage, the curd was at intervals of half an hour cut into pieces from 3 to 4 in. square and turned. When a certain consistency of the curd had been attained, it was removed, usually about eight o'clock, to the 'dripper', a sort of draining rack or cooler. At this stage it was tied in cloths and lightly pressed so as to expel more of the whey. The curd was cut into pieces and turned every twenty or thirty minutes, the weight being increased after each breaking up of the curd. When the curd had become properly drained and matured it was cut or broken into small pieces by an S-shaped knife, salted, and filled in the hoops or chessets.

The curd was not immediately pressed, but allowed to stand in the chesset for some hours in a high temperature, either before the kitchen fire or in a dry boiler which had been in use during the day. The high temperature caused the curd to ferment and the whey to drain freely in consequence. The curd was usually salted about five o'clock, and the after-treatment differed little from that of the present day.

Modern Method.—The Dunlop cheese of the present day are manufactured on Cheddar principles, and the softer texture and milder flavour are obtained by certain modifications in the process at different stages. More moisture is retained in the curd, and to obtain this less rennet is used, and the curd is not cut so fine; a lower temperature of scald is adopted, and in consequence less whey is expelled from the curd during cooking. At the time the whey is drawn, the curd is softer and sweeter. Also the draining of the curd after the whey has been run off is not so rapid or thorough, but a method of slow and gradual draining is adopted, and the pressure of the extra moisture causes a greater mellowness in the curd. Owing to the greater amount of moisture retained in the curd throughout the process, the acidity should be developed to a correspondingly less degree than in Cheddar making. Acidity will develop more rapidly with the more favourable conditions, in consequence less starter is used, and less ripening of the milk allowed before renneting. The whey is run off the curd considerably sweeter, and more of the necessary acidity developed later on the cooler before salting.

It is found in practice that by developing the acidity in the cooler after the whey is drawn there is less tendency to a hardening of the curd, and it is more conducive to a mellow and close texture in the cheese. The acidity in the curd at salting is rather less than for a Cheddar, viz. ·65 to ·75 per cent on the acidimeter.

Instead of giving the process in practical detail we will confine ourselves to drawing attention to those points in the treatment which differ from the process of Cheddar making.

The starter employed is the same, but less is added, and the quantity should not exceed ¼ per cent.

The milk is renneted considerably sweeter, and the temperature of renneting is usually from 82° to 84° F. The consistency of the curd when broken is rather softer than for Cheddar; after breaking or cutting, the stirring and heating are continued until the temperature of scalding is reached. This is usually 94° to 98° F., according to the varied conditions present, which influence the cooking of the curd.

The whey is drawn from the curd when fine threads of from ⅛ to ¼ in. will show on the hot iron. The curd is removed from the vat to the draining rack in the cooler, and immediately piled up to a depth of about 6 in., care being taken not to stir off too much free moisture, which is an important factor to assist in bringing about a proper fermentation.

The subsequent treatment is somewhat similar to that in Cheddar making, except that the curd is less acid when salted, and less salt is added, usually about 1 lb. to 56 lb. of curd.

Many makers of fine Dunlops prefer to drain the curd in the vat for the first half-hour after drawing the whey, believing that a softer and closer texture with milder flavour results. In this case the whey is removed sweeter than when drained in the ordinary way, and the curd gently piled at the sides of the vat, which is tilted to allow the whey to drain off. The curd remains here for half an hour, and the whey gradually drains away. With this process more moisture is retained, and fermentation proceeds more rapidly than when drained and stirred in the ordinary way on the cooler.

After twenty-five to thirty minutes the curd is cut and torn into pieces about 3 in. square, removed to the cooler, tied up in ordinary press cloths and put under light pressure: about 28 to 56 lb. of curd. This gradually removes the excess of moisture retained in the curd up to this point.

The curd is broken up and turned each half-hour with continuous pressure until ready for milling, after which the treatment is as before.

Curing.—The curing room should be kept dry and well ventilated, and at a uniform temperature of 56° to 60° F. The Dunlop cheese requires a rather lower curing temperature than Cheddar, from the fact that it contains a higher percentage of moisture, which hastens the ripening process. Cheese made and kept in this way will be ready for marketing in from six to eight weeks, and will keep for three months under favourable conditions of temperature.

Features.—A typical Dunlop cheese differs from Cheddar in shape, colour, texture, and flavour. The shape is much flatter than that of the Cheddar, so that these varieties are often termed 'flat cheese' and 'deep cheese' respectively. The fashionable shape at present is 16 in. wide and 9 in. deep. A cheese of these dimensions represents from 68 to 70 lb. of salted curd. The cheese should be well finished with a symmetrical form, neat edges, and a smooth, clean surface. The colour desired is creamy-white, the natural colour, though this varies according to conditions, and different shades of colour are found. In the spring, when cows are wholly house-fed, the colour is paler, and many makers then add a few drops of annatto to the milk to secure a colour resembling that of the summer months. Usually 1 dr. of colour to 100 gal. of milk is sufficient. It is also found that with excessive moisture or acidity in the curd the colour becomes bleached to a greater extent than usual, with the result that the cheese is paler or more 'chalky' in colour. Thus the colour of the Dunlop cheese is some indication of the acidity.

The texture of this variety of cheese is probably its most distinctive feature. It should be softer and more mellow than that of the Cheddar. The Dunlop contains more moisture, and in consequence ripens faster and will not keep so long. The solids are less thoroughly preserved than in the Cheddar, but better adapted for early ripening and early consumption. A greater weight of ripe cheese is obtained from the milk; the price per cwt., however, as a general rule is proportionately less, so that the cash returns of the two systems are practically the same. The flavour of a prime Dunlop cheese is also characteristic. It should be mild and creamy, and free from acidity or bitterness. The pleasing flavour, however, usually is less permanent than in the Cheddar, owing to the greater degree of moisture in the curd, and the cheese are more liable to develop a sharp, though not unpleasant, flavour in keeping. The Dunlop is a popular cheese for toasting purposes, and in many districts it has been gaining in favour, and is more in demand than formerly. [R. J. D.]

Durability of Materials.—*Timber.*—The durability of timber depends largely upon the conditions under which it is placed. If kept dry and well ventilated, or buried in the ground, or completely submerged, all varieties of timber are equally durable and will last indefinitely. Sound logs of oak, pieces of pine, &c., have been unearthed after having been buried at considerable depths for centuries; and parts of the piles of the lake-dwellers, driven over two thousand years ago, are still quite sound and intact. When exposed to the weather, however, all varieties of timber tend gradually to decay, but some are more durable than others. For example, teak, oak, greenheart, and jarrah are much more durable than pitch pine, ash, and larch; while these latter are more durable than beech, red pine, elm, birch, and spruce. The worst situation in which timber can be placed, so far as its durability is concerned, is that of alternate dryness and wetness, especially if accompanied by heat and confined air; and when exposed to confined air alone, without the presence of any considerable quantity of moisture, decay by 'dry rot' results, accompanied by the growth of a fungus which reduces the wood to fine powder. Fungus growth, which is the cause of the decay of timber, may be prevented, or destroyed, by thoroughly filling up the pores of the wood with some preservative liquid, such as creosote, copper sulphate, chloride of zinc, or

bichloride of mercury. Sap in wood tends to cause decay by its decomposition, and therefore timber should be felled when it contains the least sap, for it will then be most durable. When properly seasoned, timber may be protected against decay by coating it with oil paint, or tar, or by charring the outer parts of it; but if the timber be not properly seasoned, coating or charring it in this way only renders it more liable to fall a prey to 'dry rot'.

Creosoting.—It is now generally recognized that creosoting is the best process for the protection of timber against rot and attacks of insects. This process consists of impregnating the timber with creosote oil, or a mixture of coal-tar distillates of high boiling-point; the impregnation being effected by painting, by dipping, or by saturating under pressure. The primitive method of simply painting the surface has been found to lengthen the life of the timber to a certain extent. The method of dipping, or immersing, is carried out in sheet-iron or masonry tanks in which the creosote oil is kept at a high temperature, the duration of the immersion varying according to requirements from a few minutes to several hours. The best and most effective method, however, of impregnating timber with creosote is that of saturating under pressure, which is carried out as follows: The cut timber, after having been well seasoned, is carefully packed in a creosoting cylinder having semi-spherical ends, one of which forms the door. The door having been made tight, the timber is sometimes, but not always, steamed for 40 or 50 minutes and then subjected to a vacuum. Hot creosote is then admitted, and, when the cylinder is full, force-pumps are started which raise the pressure, in some cases, to 100 or 120 lb. per square inch, the pressure applied depending upon the kind of wood treated. After being subjected to pressure in this way for about 40 minutes, the normal pressure is restored, the excess oil run off, and the door removed.

Structural or Building Stone.—The durability of a building stone depends upon its power of resisting the disintegrating actions of water, heat and cold, frost, and the chemical action of the atmosphere. The most destructive of these agents, in the case of the relatively impervious stones, is the variations of temperature, which cause alternate expansions and contractions to take place; but in the more porous and absorbent stones it is rain or a moist atmosphere, which, by the freezing of the absorbed water, or by its chemical action, causes decay.

The air of large towns always contains more or less deleterious acids; these acids are dissolved by the rain, which, being absorbed in part by the stone, combines with its constituents. Hence, in one district, far inland, and where the atmosphere is pure and the temperature very equable, the life of a stone may be many hundreds or even thousands of years; while in another, near the seacoast, or where much coal is burned, it may begin to scale and crumble away in a few years. The most durable of rocks are the unstratified rocks, such as granite and syenite, which, for the most part, are hard, compact, and strong. The durability of sandstone rock, which consists of particles of quartz cemented together, depends upon the nature of the cementing material; and when this is silica the stone is very durable, but when it is calcium carbonate the stone is somewhat readily injured by the weather. With limestone the durability is greater the more compact it is and the less water it can absorb. There are many different tests — freezing, absorption, microscopic, and chemical—which are used in practice for determining the comparative durability of stones of the same kind, but a single illustration of the actual weathering of stone from the same quarry in a building, monument, or slab is worth more than all the artificial tests which can be applied.

Road Stones.—The durability of a road stone depends partly upon its resistance to mechanical abrasion and partly upon its power to withstand chemical decomposition. Granite, syenite, basalt, and whinstone are very durable, and are largely used for paving and macadamizing roads.

[H. B.]

Durham Cattle, a name formerly applied and sometimes still applied to Shorthorn cattle on account of their having originated in the county of Durham. See SHORTHORN CATTLE.

Durmast. See OAK.

Duroc Jersey Pigs.—This breed of pig is claimed by our American cousins as one of their home-made breeds. It may so be; but we have had in this country a type of pig which, save in what is called in the United States the broken ear, is so exactly similar in form, character, and colour, that the foundation of both of these sub-varieties might have been the same. This peculiarity in the hang of the ear, which has been described as half erect and half drooping, is found in one or two other types of American pigs, the most extensively bred Poland-China, for instance, and may have been derived from an infusion of the blood of a Cambridgeshire, Bedfordshire, Lincolnshire, or even a Cheshire pig, all of which had long pendent ears covering the snout of the hog. Another of the foundation hogs was undoubtedly the Staffordshire mahogany or dark-chestnut-coloured pigs, with black spots on the skin, long snout, and pricked ears. Be the crosses what they may, the result is a thick-fleshed, quick-growing, hardy, and prolific pig, which is fast taking the place in the States of the fashionably bred Berkshires and Poland-China pigs, mainly owing, it is said, to the breeders of the latter kinds paying far more attention to the fancy than to the useful points of their pigs. This is the excuse frequently made for that want of prolificacy, hardihood, and muscle in pedigree stock, whose votaries men are of unlimited means but limited experience of practical stock breeding and feeding. Another reason for the decadence may be that the live stock of mere fanciers is too often b..ed more with a view to success in the showyard than in the mere commercial livestock world, a tendency towards shyness in breeding and a weak constitution being overlooked when the sire or dam possesses some fancy points which at the particular period may be fashionable. The breeders of the Duroc Jersey pig are now experiencing a very keen de-

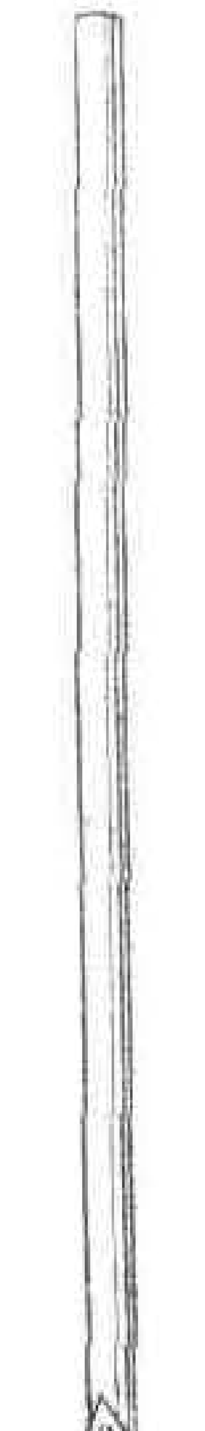
mand at almost fabulous prices—£400 in one or *more cases—and they will be more than human* if they are not led to think too much of pedigree and too little of pig. In our opinion the Duroc Jersey might be improved in its quality of bone, skin, and flesh; too much attention has apparently been paid to the consumption of maize and the filling of the pork tub or barrel. The length of body should be increased, so that the pigs will be more suited for the fresh pork or the bacon trades, since the demand for these two classes of meat is enormously increasing, not only in America, but in most parts of the world. [S. S.]

Dutch Barn. See HAY SHED.

Dutch Cattle. See FRISIAN CATTLE.

Dutch Clover, another name for White Clover (*Trifolium repens*). See CLOVERS.

Dutch Hoes.—Dutch hoes differ from ordinary drag hoes in that they are used with a pushing instead of *a pulling action. They are employed* more frequently in the garden than on the farm, though they are serviceable in market gardening, as they can be used to cut up weeds growing in crop rows where it is not convenient to insert a drag hoe. As they can be used while the operator walks backward, he does not tread on the freshly moved soil, as he does when using the drag hoe. [W. J. M.]

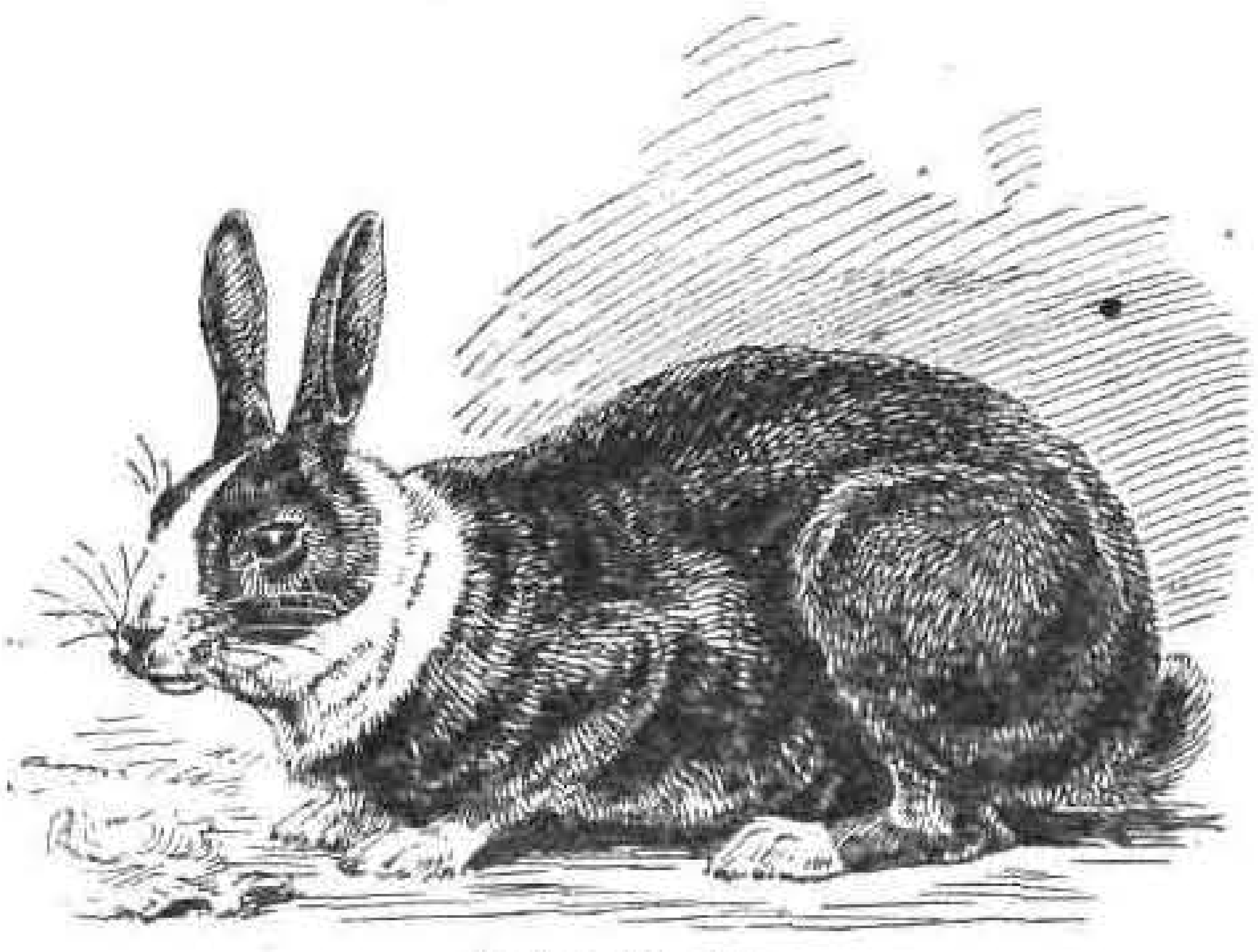


Dutch Hoe

Dutch Rabbit.—This is one of the smaller breeds of fancy rabbits, though an exceedingly popular variety, being good breeders and hardy, which is a recommendation not only in rabbits, but also in other stock.

The Dutch Rabbit originated in Holland. *Through careful selection the breed* has greatly improved during the last few years, and now a rabbit about 5 lb. weight is looked upon with most favour by breeders of Dutch rabbits. Some are too big, others undersized, both of which faults are detrimental for the show pen.

In colour the body may be sandy, blue, black, tortoise shell, sable, &c., the markings being white. Particular attention is paid to uniformity of the markings, in fact this constitutes one of the essential features of the breed. Where the white and body colour unite, the line of junction should be as clearly defined as possible—the sharper the better. The most fashionable colour is the tortoise shell, and high-class speci *mens are eagerly sought after. Odd-coloured eyes, and 'speck' in* the eyes, as well as irregular markings, are the chief defects of this variety of rabbit. There should be white points or 'stops' on the hind feet, and these stops ought to extend upwards from the toes to about 2 in. The whole of the neck, fore-quarters, and legs have white *upon them, that portion around the neck being* referred to as the collar. The line of junction between the body colour and white must be



Dutch Rabbit

sharply defined—sharper the better. The muzzle is white, and there is an extension of this mark*ing upwards in the form of a 'ratch', i.e. a white* stripe or blaze, which ultimately blends with that of the collar. The face markings are black, so are the ears, if the body colour is black, but the markings must always be uniform. Sometimes the 'ratch' stops short just about the level of the eyes, and this is most detrimental for exhibition purposes.

The coat requires to be short, but dense; any tendency towards a 'thin' condition of the coat is objectionable. Essentials are: lustre, shortness, and density of coat. Nearly 50 per cent of points are allotted for quality in connection with the blaze and collar, and the aim of the Dutch Rabbit breeder is to excel in this respect.

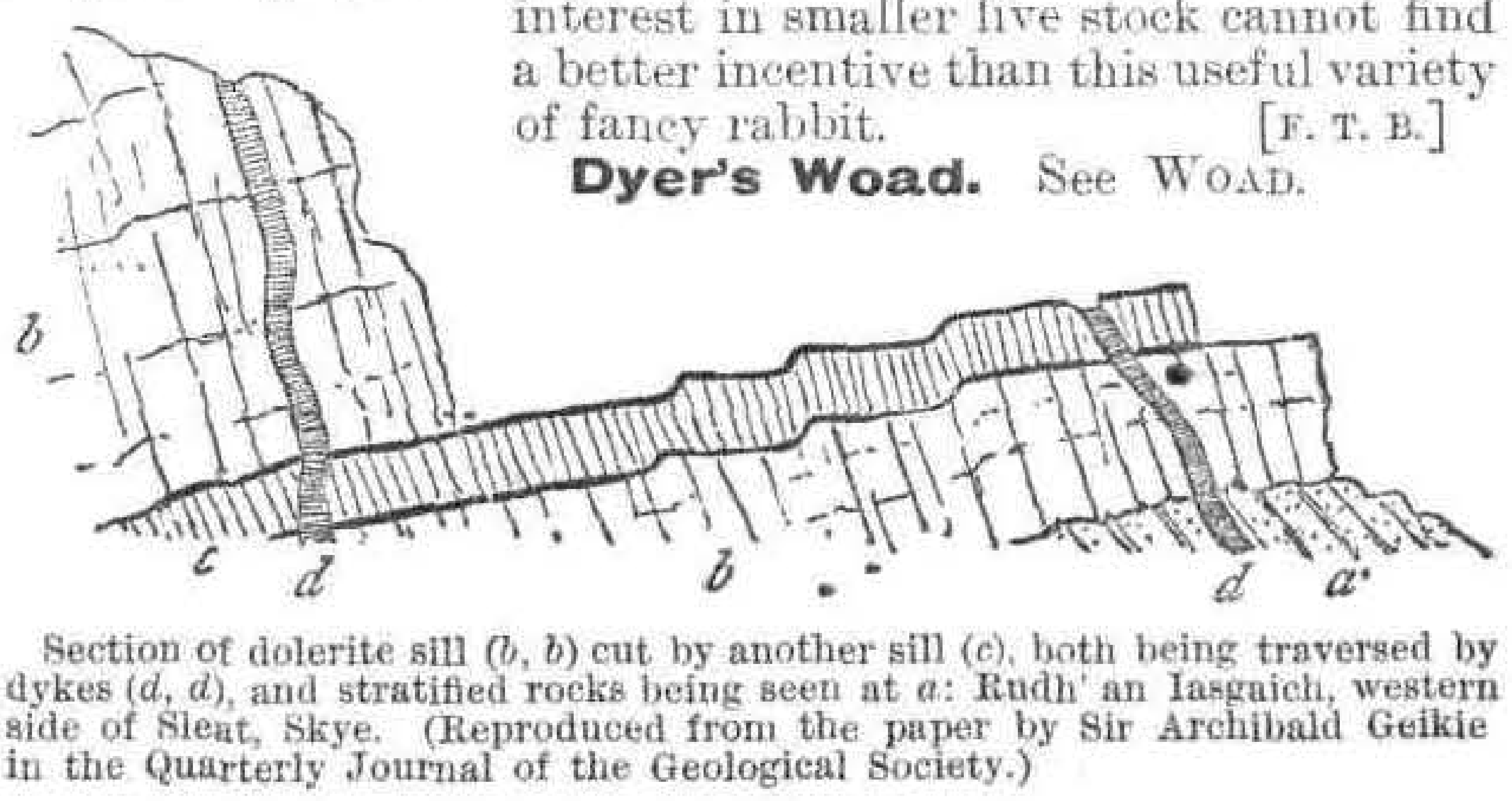
The general conformation of these small rabbits should be that of compactness, in fact the Dutch Rabbit is singularly neat in his appearance. The does breed freely, usually having *from six to nine at a kindling.*

As previously stated, this is a hardy variety, so that it thrives well either in- or outdoors.

In mating say a blue-and-white doe, the best plan is to select a buck having black for the ground colour.

Farmers and others anxious to encourage the junior members of the household to take an interest in smaller live stock cannot find a better incentive than this useful variety of fancy rabbit. [F. T. B.]

Dyer's Woad. See WOAD.



Section of dolerite sill (*b*, *b*) cut by another sill (*c*), both being traversed by dykes (*d*, *d*), and stratified rocks being seen at *a*: Rudh' an Iasgaich, western side of Sleat, Skye. (Reproduced from the paper by Sir Archibald Geikie in the Quarterly Journal of the Geological Society.)

Dyke.—When molten rock ascends by a fissure within the earth's crust, it may ultimately

cool there, and form a hard mass resembling a wall. Weathering may remove the surrounding rocks more easily, and the igneous mass may stand up on the surface, a character that has led to its being called a 'dyke'. Such are the familiar 'whinstone dykes', commonly consisting of dolerite, which form obstacles to farming. On the other hand, some dykes may decompose more readily and give rise to grooves, particularly where attacked by the sea. When dykes run along planes of bedding, like those in the limestone near Carlingford in Co. Down, or Salisbury Crags at Edinburgh, they are called *intrusive sheets* or *sills*. [G. A. J. C.]

Dynamo, a machine used for transforming mechanical energy of rotation into energy in the

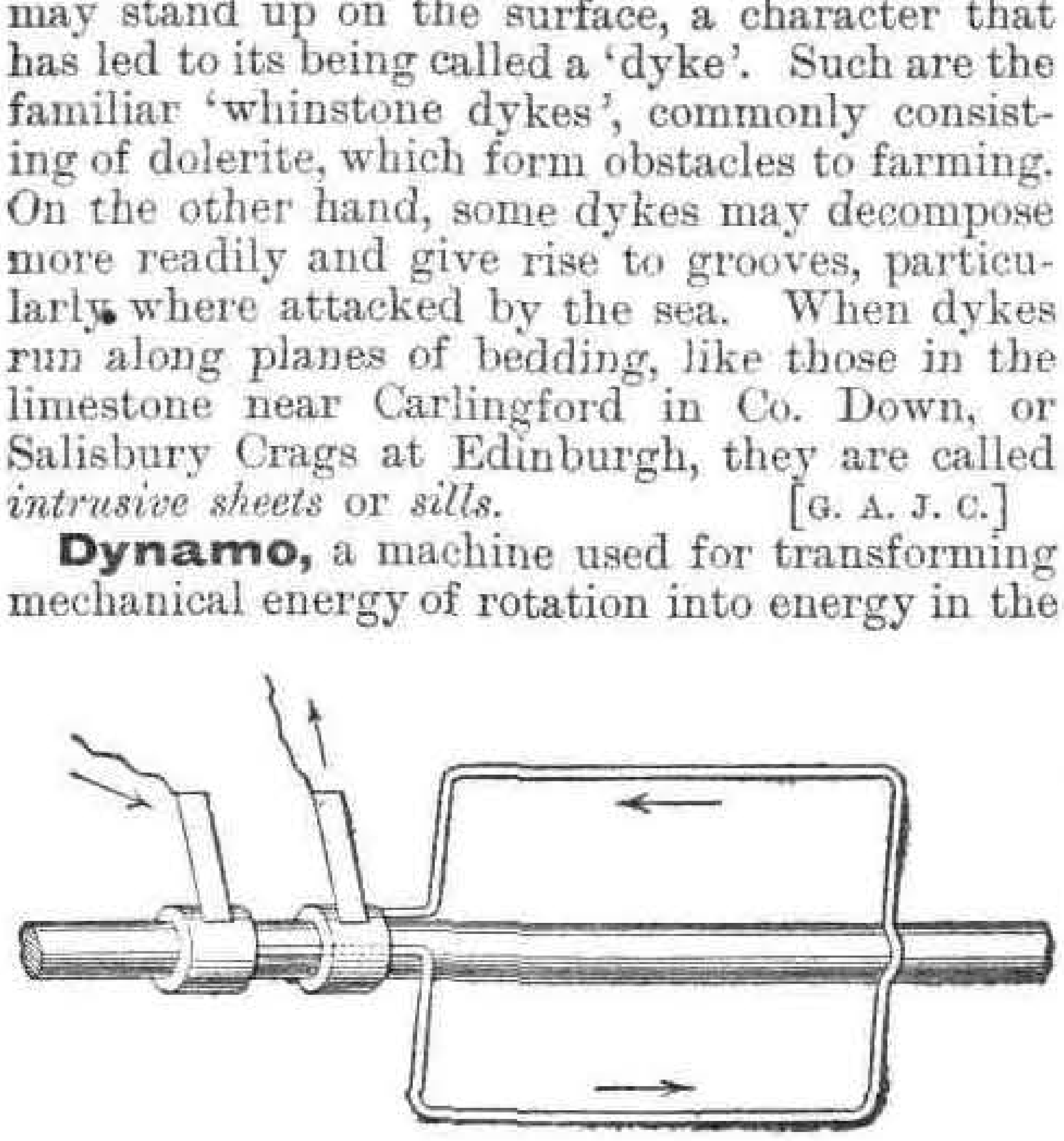


Fig. 1

form of an electrical current. When a piece of copper wire, bent, say, in the form of a closed rectangular coil, is rotated between the poles of an electromagnet, it is found that an electrical current is generated which circulates round the closed coil in one direction during one half of each revolution, and in the reverse direction during the other half. It was the discovery of this phenomenon which led directly to the invention of the dynamo. Now suppose the coil to have two adjacent loose ends, and be mounted upon, but insulated from, a shaft, and the loose ends connected, as shown in fig. 1, to two metal rings, also mounted upon and insulated from the shaft. If two strips of copper connected by a piece of wire be then made to press upon the metal rings, we obtain an alternating current dynamo of the simplest possible form, and if the shaft be made to rotate, a pulsating current of electricity will circulate backwards and forwards through the coil (now called the armature), the brushes or strips of copper, and the outside circuit. Such alternating currents are not always suitable in practice, and it is therefore often necessary to make use of a device, called a commutator, for rendering the current continuous in the outside circuit. This may be done in the above simple dynamo by replacing the two metal rings by a metal tube split, in a direction parallel to its axis, in halves; the metal brushes, one of which is in contact with one half of the tube, and the other with the other half, being so arranged that, at the moment of the reversal of the current in the armature, each half of the commutator slips out of contact with one brush and comes in contact with the other. In this way the currents which are generated in alternate directions in the armature coil are made to flow in one direction through the outside circuit.

A continuous-current dynamo, therefore, consists of three main parts—the *armature*, the electro- or *field*-magnets as they are called, and the *commutator*.

The armature of an actual dynamo consists of many coils of cotton-covered copper wire wound round an armature core. This core consists of a large number of very thin flat rings—in the case of a ring armature—of charcoal iron, the rings or disks being insulated from each other by sheets of thin paper, and pressed together so as to form a hollow cylinder. The armature is mounted upon a steel shaft, to which it is keyed by a four-armed gun-metal (non-magnetic) spider, the extremities of the arms of which fit into notches cut in the inner edges of the iron core-rings.

There are many types of armatures used in practice—ring armatures, drum armatures, and disk armatures. A modern type of ring armature is shown in fig. 2. In this armature the adjacent ends of neighbouring coils or sections of the armature winding are soldered to radial arms projecting from the commutator bars. The commutator, C, is composed of the same number of copper bars as there are sections in the armature winding, and each bar is insulated from its neighbours by mica strips.

A direct-current dynamo is shown in fig. 3, in which the pole pieces of the field magnets are shown enclosing the armature, and the commutator, with the brushes pressing on its segments, is shown on the right. These brushes, instead of being copper strips as shown in the figure, are now generally made of prepared carbon, are square in form, are carried in boxes or brush holders, and are pressed down upon the commutator segments by means of springs. The field-magnet cores have many convolutions of insulated copper wire wound upon them, and the magnets are excited by sending a direct current through these coils. This current may be supplied: (1) Separately from a storage battery, or from another dynamo; (2) by passing the current generated by the dynamo through the field-magnet coils before passing it through the outside circuit, when it is called a series-

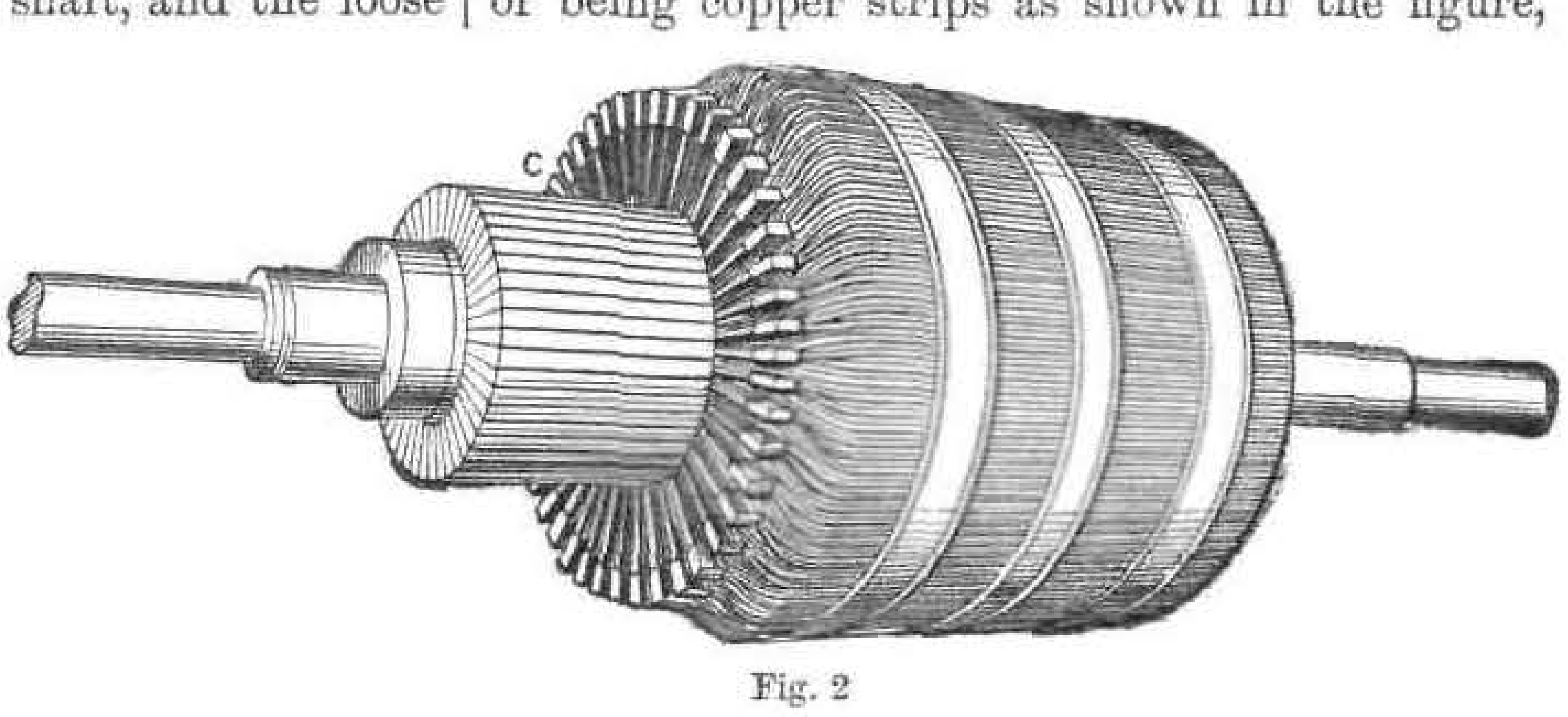


Fig. 2

wound dynamo; (3) by passing a small portion only of the current generated by the dynamo through the field-magnet coils, and the rest through the outside circuit, when it is called a shunt-wound dynamo; or (4) by passing the current sent through the outside circuit through a few turns of thick copper wire wound round the cores of the field magnets, and a further smaller current, *shunted* from the main current at the brushes, through field-magnet coils con-

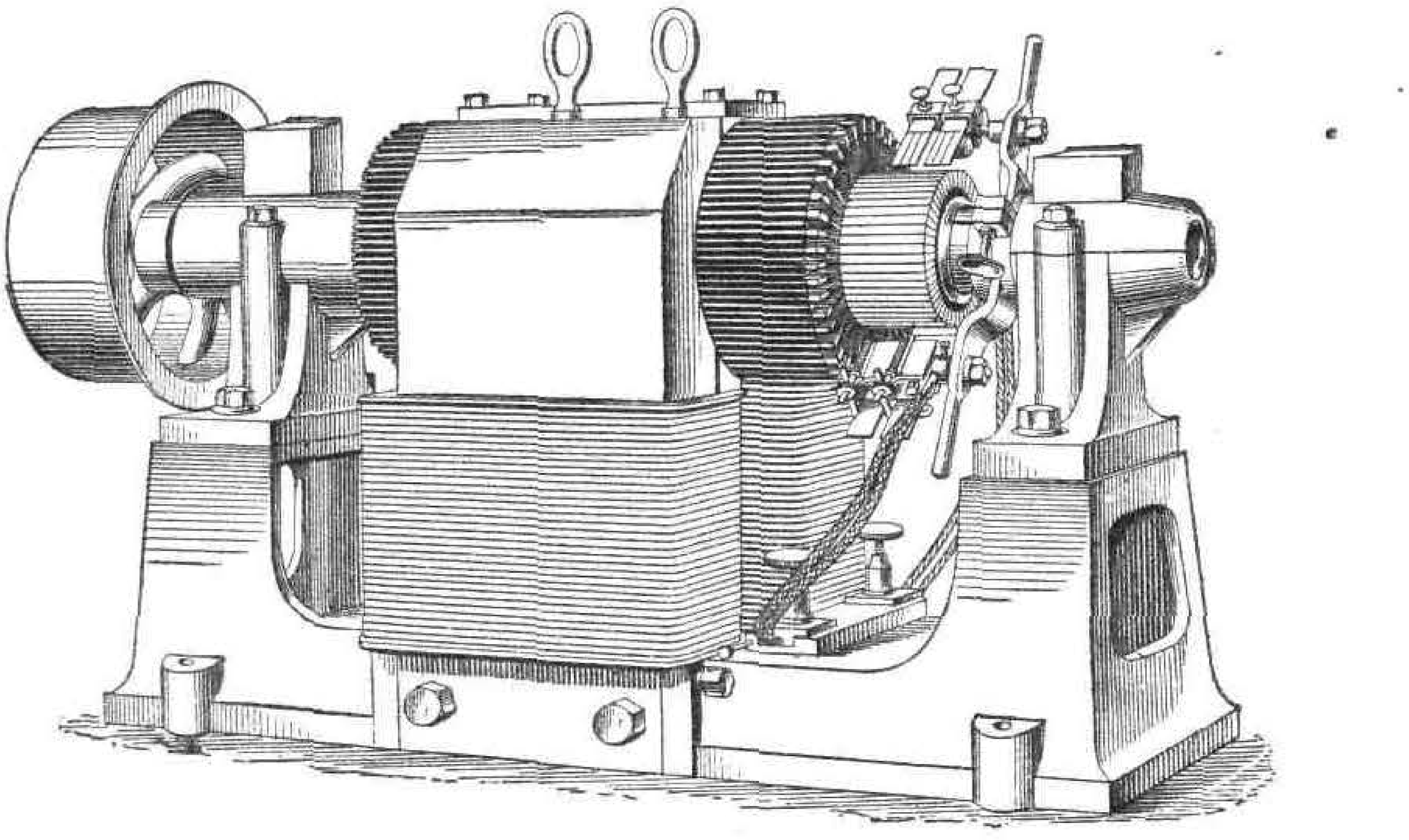


Fig. 3

sisting of a large number of turns of fine wire, when the dynamo is called a compound-wound dynamo. [H. B.]

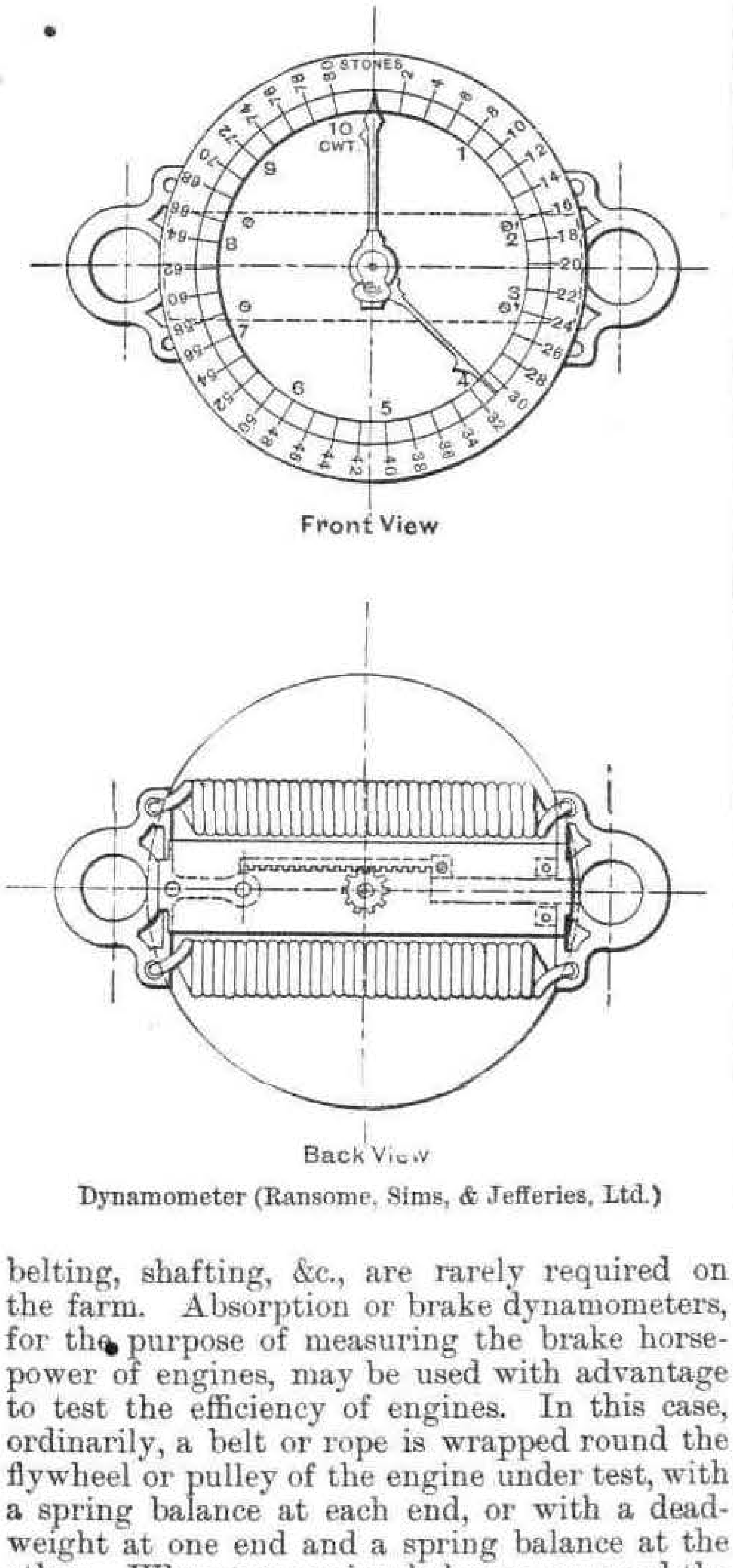
Dynamometers. — Dynamometers are used to indicate or measure the force exerted by animals or machines, or of parts of machines; and although special instruments are designed to measure the work done by horses and machines, and are more particularly regarded as dynamometers, many simple instruments in everyday use, and known under other names, are in reality dynamometers. An ordinary pair of scales measures the force with which the earth attracts any substance to be weighed, the weights required to compensate this attraction being the measure of the force exerted. The spring balance is a simple form of weighing machine, which is the parent form of many dynamometers, the resistance of the spring being overcome by the weight attached so far as to produce an equilibrium, this force being indicated on a gauge or dial marked to measure it in pounds, tons, or other recognized divisions. An adaptation of this form of spring balance is used to denote the resistance made by a plough, wagon, or other implement worked on a farm. A stout spring is conveniently attached to a dial, the face of which is marked with figures graduated to indicate, by means of an indicator finger, the pull exerted by the horses. When testing the draught of a plough the dynamometer is attached to the draught chain by means of a hook placed on the frame of the dynamometer; the spring at the opposite end to the hook is attached to the whippletrees, and as the horses exert their force the spring yields and the indicator moves in sympathy with it, so that the resistance or force exerted may be read off. This form of dynamometer may be used wherever it can be placed in an intermediate position between the implement and the horse or other motive force employed. Farmers would have a far more accurate idea of the draught of their machines were they to occasionally use a dynamometer; and there are many circumstances when they could do it to advantage. We may illustrate this through a series of trials we made between the old type of single-furrow plough and the modern chill breast-digging plough. These were new ploughs made by a well-known firm, on a moderately light loam, drawn by a pair of horses.

	Old Type.	Digging Plough.
Depth of furrow ...	$7\frac{1}{8}$ in.	$7\frac{5}{8}$ in.
Width of furrow ...	11 in.	14 in.
Starting pull	$4\frac{7}{8}$ cwt.	$4\frac{1}{2}$ cwt.
In motion	$3\frac{5}{8}$ cwt.	$3\frac{3}{4}$ cwt.

This shows definitely the lighter draught of the digging plough, and when purchasing other machines it would certainly be advantageous to know definitely the relative power required to work them.

The steam gauge is a dynamometer for measuring the force of pressure exerted on each square inch of the interior of the boiler. The steam gauge can be placed in any convenient part of the boiler, as the pressure is equal throughout. It is usually placed conveniently for the driver to read it when at the driving lever. The gauge is placed in a hole bored to admit the steam without other resistance than that which it exerts directly on the spring, and the pressure exerted, by driving the spring in-

wards, actuates the pointer so that the number of pounds per square inch is shown on the dial. The pressure of gases may be measured in a similar manner. Dynamometers are used to measure forces of any description, such as twisting forces, where the torsion dynamometer is employed; but these, and transmission dynamometers for measuring power transmitted by belting, shafting, &c., are rarely required on the farm. Absorption or brake dynamometers, for the purpose of measuring the brake horse-power of engines, may be used with advantage to test the efficiency of engines. In this case, ordinarily, a belt or rope is wrapped round the flywheel or pulley of the engine under test, with a spring balance at each end, or with a dead-weight at one end and a spring balance at the other. When two spring balances are used the difference between them gives the force applied at the rim of the flywheel or pulley; and where one spring balance is used the difference between this and the deadweight gives it. The horse-power is calculated, when the speed of the engine is known, by the following rule:—



Dynamometer (Ransome, Sims, & Jefferies, Ltd.)

H.P. = force applied at rim in lb., multiplied by the circumference of the wheel in feet, multiplied by the revolutions per minute, and divided by 33,000. [W. J. M.]

Dysentery.—This is a disease of the bowels not uncommon in the dog and in foals; less frequent in cattle. The condition is attended with fever, occasional abdominal pains, and fluid discharges mingled with blood. The evacuations are coffee-coloured or bloody, liquid, and offensive in odour, and passed with much straining.

Causes.—A diarrhœa of long standing often terminates in dysentery. The ingestion of decomposed foods or the presence of worms in the bowels is often the cause. Too continued use of irritant drugs or medicines given indiscriminately may also produce it. Other causes are the existence of some disease, as tuberculosis, of the abdominal form; and dysentery may arise in suckling foals from feeding the dam on irritant foods or from disease of the udder.

Symptoms.—Diarrhœa, the ejecta being of an extremely offensive character often tinged with blood containing very hard small lumps, and often much frothy or stringy mucus. They have an acidity which leads to excoriation around the anus, and to frequent tenesmus, especially in the dog. There is much straining, and the animal suffers from fever and abdominal pain, and there is rapidly increasing emaciation, so that very soon after the commencement of the attack the patient is in an extreme state of debility, and its breath and cutaneous emanations smell foul and sickly. Thirst is a prominent symptom. In the dog the stomach is also occasionally involved in this disorder, and then persistent vomition is a marked symptom, although the appetite may be ravenous and depraved. It is also specially noticed in this animal that paralysis sets in a few days before death.

Treatment.—This is most unsatisfactory, and requires to be prolonged and very careful. Husbanding the strength by every available means is necessary. The animal must be kept in a dry, warm bed and clothed with blankets. Broth, eggs, beef tea, milk, cod-liver oil, and other nutritives may be given by the mouth, and also mixed with astringents *per anum*. Medicinally give catechu, laudanum, or chlorodyne in small doses oft repeated. In spite of the best care and treatment, however, dysentery is likely to prove fatal. [H. L.]

Dziggetai, the wild ass of Mongolia. See Kiang.

E

Eagle.—There are two species of eagle resident in Great Britain, of which one has lately shown signs of an increase in numbers, and the other of a decrease. The species which is increasing is the Golden Eagle (*Aquila chrysaëtus*), which, however, is still confined almost entirely to the Highlands of Scotland. At infrequent intervals a wanderer may appear in an English county, and somewhat more often in the Lowlands of Scotland. For many years past it has not bred outside the Highlands and islands on the west coast of Scotland, though quite recently it has attempted unsuccessfully to return to one of its old breeding haunts in the most mountainous part of the Lowlands. In Scotland it is frequently called the 'Black Eagle'. The other British species is the White-tailed Eagle (*Haliaëtus albicilla*), often called the Erne, or Sea-Eagle. Formerly it used to be not uncommon in the north-west of England and west of Scotland, but its numbers have now considerably diminished, and its eyries are confined to the northern and western islands of Scotland. Immature examples of this species are occasionally seen on the English coasts in the autumn and winter, passing southwards on migration. Eagles are very voracious birds. The Golden Eagle lives largely upon mountain hares, but takes almost any kind of bird or young animal. The White-tailed Eagle eats almost anything that comes in its way, including carrion as well as living animals. [H. S. R. E.]

Ear, Diseases of the.—Horses, cattle, and sheep are remarkably free from diseases of the ear, a deaf one being scarcely known except as the result of severe injury to the head by falling of heavy weights, as in coal mines where ponies are employed. The thinness of the integumentary covering of the cartilage of the pig's ear makes him liable to suffer from extremes of heat and cold, and mortification and loss of a portion of an ear is not rare; but he is not more subject to true diseases of the organ than the species above mentioned. The adjacent glands (parotid) may be the seat of disease in which the ear sympathizes more or less, a malady which is considered elsewhere. Dogs are peculiarly liable to ear troubles, and the farmer's and sportsman's are not less prone than the pampered pet dog. The disease known as canker should be considered rather as a common result of several conditions precedent to it, the most frequent of all being the presence of ear mites (*Symbiotes auris canis*), which set up irritation, to be developed only by the sufferer's futile efforts to allay the itching by striking at the base of the ear with the hind foot. Accumulated wax and dust, or the invasion of lice or other parasites, may lead to the same conduct on the part of the dog, and with the like result of setting up such an inflammatory condition of the lining membrane, that an ichorous discharge presently issues from cracks which have formed in the meatus. A simple otitis or inflammation of the ear unassociated with parasitism has been of more frequent occurrence since the advent of motor vehicles and the heavier particles of grit raised by their suction from the road. What has been generally known as outside canker is either an injury to the flap of the ear and ulceration (see ULCERS), or the rapid formation of a serous abscess (see ABSCESS).

Treatment.—The ear should be syringed with warm water and soap, and afterwards filled with an ointment consisting of 1 part of nitrate of mercury ointment mixed with 20 parts of lard. Two or three applications of this will destroy the ear mites, after which recovery may be looked for as a result of daily dressings with such an emollient as oxide of zinc ointment, to which has been added 10 drops of pure carbolic acid to each ounce. [H. L.]

Ear Cockle, a disease in cereals caused by the eelworm *Tylenchus scandens*. See ANGUILLULIDÆ, and TYLENCHUS.

Ear Mange of Cat and Dog. See SYMBIOTES AURICULARUM.

Early Maturity, or the making of fattening animals prime for the butcher at an early age, is one of the most striking features of successful modern farm practice as compared with what was the rule a generation ago. Early maturity in its most intensive forms may not yet be universally practised, but with the great improvement in the meat-producing qualities of farm animals, and the notable demand for 'baby beef', lamb, and light-weight pigs, the age at which home-bred cattle, sheep, and swine are marketed has been sensibly reduced. Home-bred cattle are now frequently intensively fed from birth, and sent to the shambles long before they are two years old, at weights which at one time would have been considered satisfactory at nearly double that age. With regard to sheep, it is now considered that the more lambs that can be got away fat off their mothers the better they pay; while the once so common three-year-old wether and three-year-old mutton, so highly prized at one time but now unappreciated, are extinct. A considerable proportion of the sheep stock go off fat at three or four months old, the majority within a year, and few are kept beyond eighteen months. In pig feeding the day is past when it was considered good practice to commence the fattening only when the animal was eight or nine months old. Now well-bred, well-fed pigs can be made rapidly fit for the fat market, and the earlier the age the greater the profit.

The successful practice of the system of early maturity depends essentially upon two factors, viz. having the right class of animals, and the skilful use of the right kind of foods. Certain improved breeds and crosses of them, owing to their special aptitude to become prime at an early age, and to stand the strain of heavy feeding, have come to be recognized as suitable, while others not possessing both of these characteris-

Photo. Chas. Reid

GOLDEN EAGLE

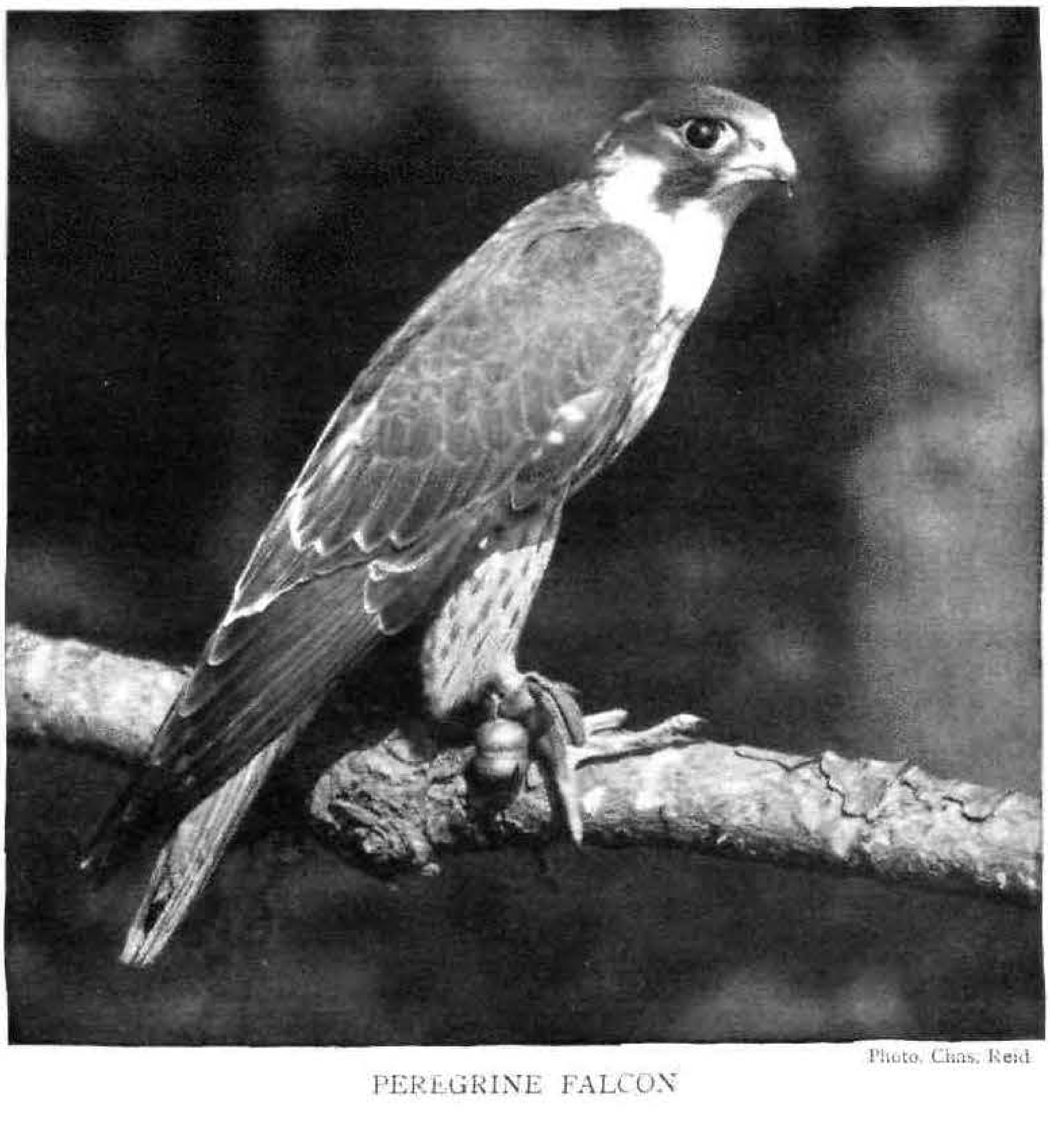


Photo. Chas. Reid

PEREGRINE FALCON

ties are unsuitable. Secondly, the animal from birth must be provided with plenty of fairly rich food of a somewhat easily digestible description, and no little skill in feeding is necessary to keep the animal in health, for there is a limit to the period during which a forcing ration can be effectively continued. An animal that endures it well for a time and makes great gains may completely break down and cease to make progress.

The propriety of adopting early maturity may be said to depend upon the suitability of the conditions, climatic and otherwise, for producing a certain type of animal, and upon the character of the food available. It may frequently be inadvisable to attempt early maturity in a bleak cold district, where animals of special hardihood, which is generally associated with slower development, is the first essential; and also in circumstances where the greater part of the available food is of a rough nature, so that an excessive proportion of the feed would have to be purchased in order to provide a suitable diet. But given favourable conditions,—and on ordinary arable farms they generally are favourable—the advantages of early maturity are great. Chemical investigation into the carcasses of fat animals of various ages helps considerably to explain why this is so. The figures given by Warington, in the Chemistry of the Farm, for cattle and sheep will serve to show how greatly the composition of the fat animal differs with age. They are as follows:—

	Fat calf.	Fat ox.	Difference.	Fat lamb.	Fat sheep.	Difference.
Water	65·1	48·4	+ 16·7	52·2	46·1	+ 6·1
Nitrogenous matter ...	15·7	15·4	+ ·3	13·5	13·0	+ ·5
Fat	15·3	32·0	− 16·7	31·1	37·9	− 6·8
Ash	3·9	4·2	− ·3	3·2	3·0	+ ·2

They bring out very clearly that the carcass of the fat calf contains over 16 per cent more water, and over 16 per cent less fat than that of the fat ox. The figures relating to the sheep are similar, although not so wide apart. From this it would seem that if the feeder can sell the young animal at the same price per unit as he would receive for the older beast, it is to his advantage. As a matter of fact, prices in recent years have been in favour of early maturity. It is the well-fed young bullock of say 10 cwt. live weight that 'tops the market', the older and heavier bullock brings a smaller price per cwt.; while lamb brings a higher price than mutton; and heavy-weight pigs are often at a discount when those of 8 to 10 st. dead weight are keenly sought after, usually at from a sixpence to a shilling more money per stone. Thus early maturity, looked at from the standpoint of composition and present-day prices, seems to be distinctly in the feeder's favour. Let us next see how this conclusion is confirmed by experience. Numerous experiments and observations that have been made on live stock show conclusively that the rapid growth of young animals is remarkable, and that they turn a very large proportion of their food into profitable channels. It has been demonstrated that a calf will sometimes gain in weight as rapidly as a fattening ox ten times its weight, this being due to the large consumption of food in proportion to the body weight, the watery nature of the increase, and the small formation of fat; and also that the increase in a fattening bullock represents nearly four times as much food as the same increase in a young calf; and of course the animal forced to early maturity occupies an intermediate position between these two extremes. Then lastly, it is obvious that with a shorter feeding period less expense will be incurred in caring for the animals, and less material required for the maintenance of the animal body. For these reasons the feeder's food is from 50 to 100 per cent more productive when used in early maturity. Besides, he can keep more stock, and his capital is turned over in half the time.

The experiments conducted at the Dominion Central Experimental Farm in Canada have a practical bearing, and provide definite information on this point. For a number of years the influence of age on the cost of making gains, or increasing the weight of bullocks, has been under investigation, with the result that it has been brought out that there is a fairly regular gradation of cost according to age. The average results show that—

	Cost per 100 lb. live-weight increase. s. d.
Bullocks from birth to 6 months ...	9 4
,, 6 to 12 months	17 1½
,, 1 to 2 years	22 10½
,, 2½ to 3 years	25 8½
,, 3½ to 4 years	34 3

These figures indicate the relative cost at different ages, and the decided advantage of getting bullocks ready for the block as soon as possible rather than letting them go till three or four years old before having them ready to kill. Bullocks fed at the experimental farm, and got ready for the block under two years old, have always left good profits; whereas bullocks kept after that age have shown a loss.

With regard to the rapid growth of the young sheep, it has been frequently demonstrated that well-nursed lambs can be grown to about 70 lb. live weight in ten to twelve weeks; but if the same class of lambs be kept till they are double that age on slightly less forcing food, they seldom add more than half that amount to their weight.

Pigs have probably received more experimental attention in respect to early maturity than either cattle or sheep. Numerous experiments in pig feeding have been conducted in

America, and the summarized results given below shed interesting light on the relation between weight or age, gain made, and food required.

Weight of pigs.	Average weight.	Number of trials.	Number of animals fed.	Average feed eaten per day.	Food eaten daily per 100 lb. live weight.	Average gain per day.	Feed required to make 100 lb. gain.
lb.	lb.			lb.	lb.	lb.	lb.
15–50	39	45	190	2·41	5·82	·78	305
50–100	79	112	508	3·62	4·58	·79	402
100–150	123	133	635	5·03	3·96	1·20	439
150–200	178	110	509	5·98	3·44	1·26	479
200–250	227	76	316	6·60	2·96	1·35	493
250–300	269	51	247	7·34	2·71	1·48	509
300–350	322	21	115	7·54	2·39	1·47	532

The last column of this table brings the fact out clearly that it requires about two-thirds more food to produce 100 lb. of gain with hogs weighing about 300 lb. than with hogs weighing 40 lb., and that there is a uniform increase in the amount of food required to produce a pound of gain as the pigs increase in weight. [W. Br.]

Early Potato Growing. See Potato.

Earmarking. — Earmarking is practised on cattle, sheep, and pigs to distinguish animals, both for ordinary purposes on the farm and also for pedigree signification, the ear being one of the few places where permanent marking can be placed without causing unsightliness. Earmarking takes different forms, such as tattooing, punching, slitting, and branding. As the ear is not a highly sensitive part of the animal, no serious or lasting pain is inflicted by any of these methods. When the ear is clear, that is, not too closely covered with hair, tattooing is

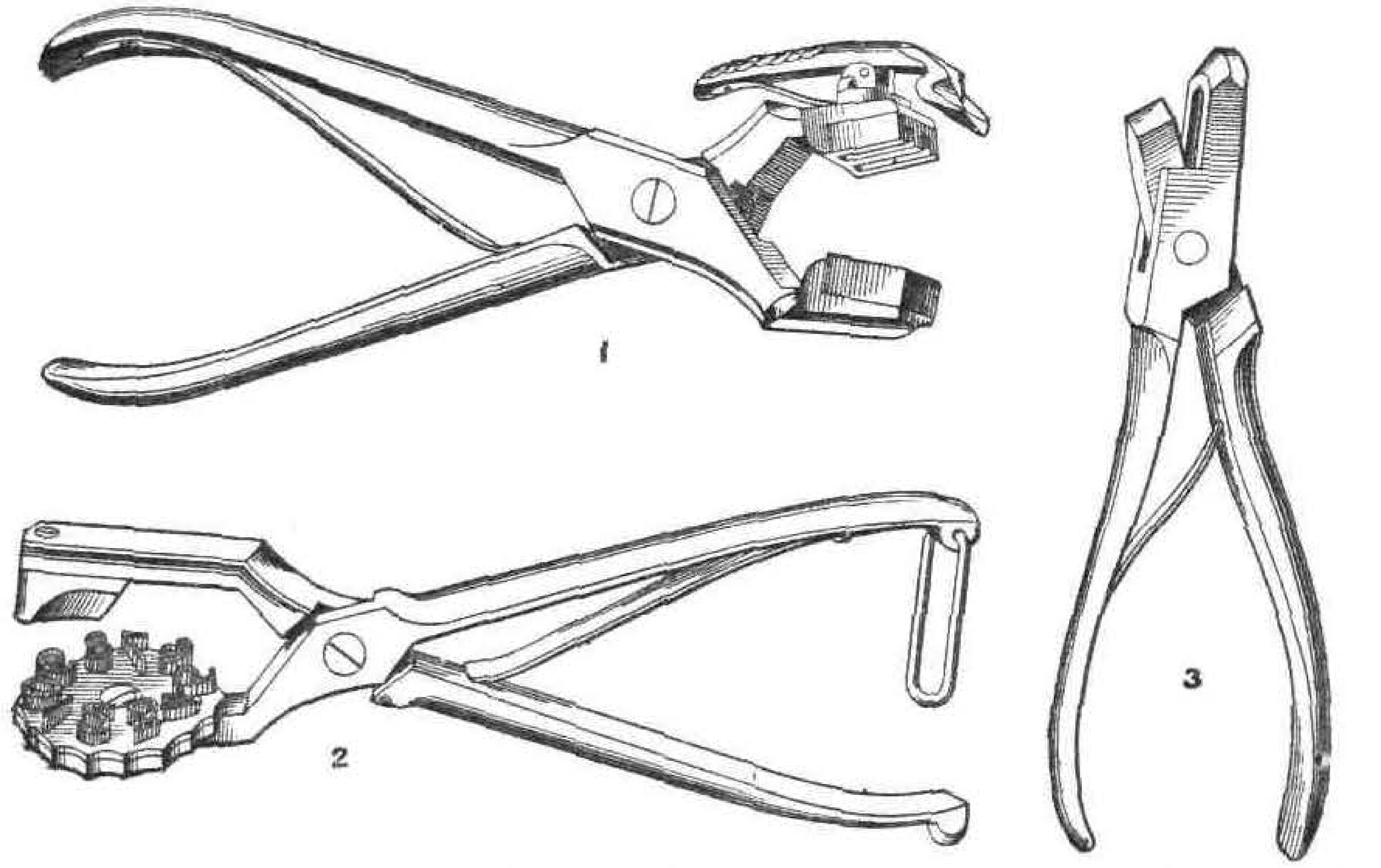


Fig. 1.—1, Tattoo Forceps for tattoo branding. 2, Tattoo Forceps with revolving plate. 3, Punch for cutting out marks on the edge of the ear.

probably the most satisfactory, for there is no outward marking, and if colour which shows in strong contrast with the skin is well rubbed in, it will remain legible for a long time. Punching is an effective means of marking, and a code representing the several numerals is devised by Messrs. Arnold, whereby with different-shaped dies any number can be inserted by punching out pieces of ear of the required shape. Punching is also employed to allow the insertion of breed societies' buttons, or metal ribbons stamped with distinctive designs to denote that the animal is in the herd or flock book of the society. The buttons employed are made self-locking, and once locked cannot be unlocked or reinserted. The chief objection to the buttons is that there is some liability for them to be torn out, through the heads being caught when cattle rub themselves, or when sheep are caught by the ear by sheepdogs. Pliers are also used to cut sections out of the edge of the ears; for these, too, Messrs. Arnold have designed codes representing numbers, which are well recognized among breeders. A very extensive code can be contrived by these in association with punch marks, especially as both ears can be used. For ordinary purposes a few simple marks are sufficient, but where a record of pedigree animals

comprising large numbers is required, it is almost impossible to identify each animal with-

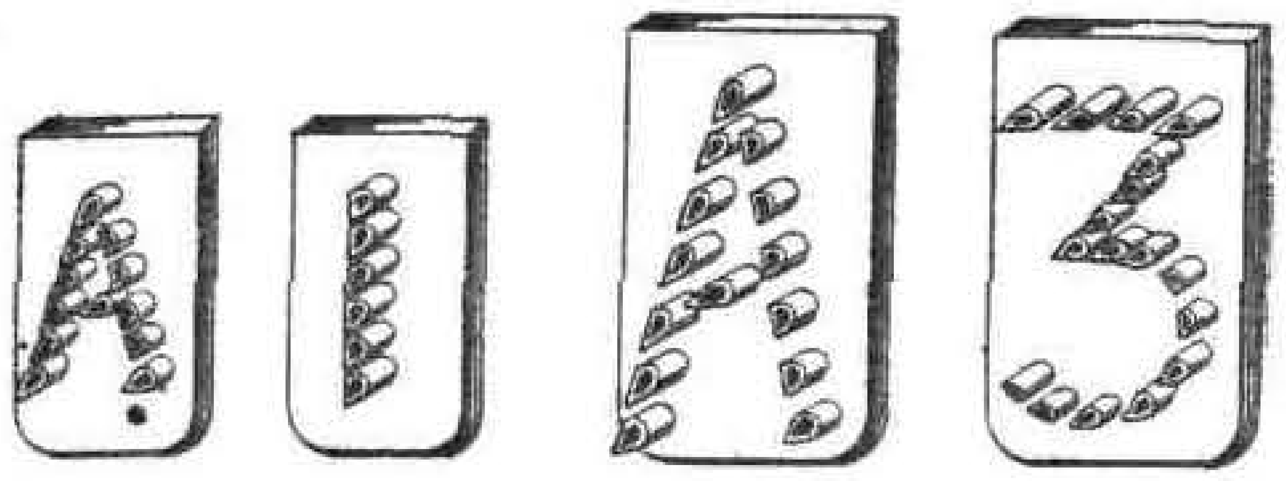


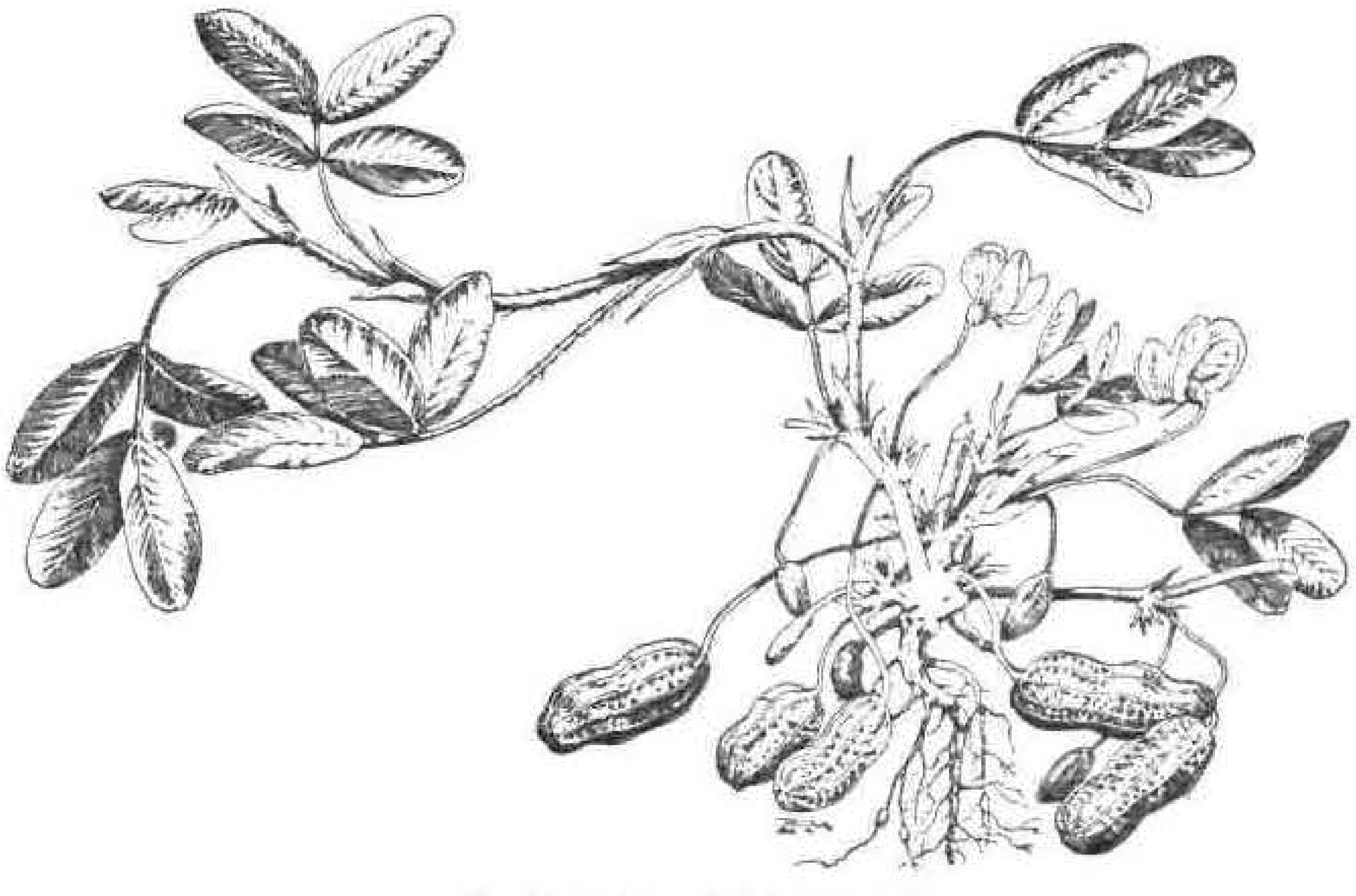
Fig. 2.—Examples of Letters and Numerals for Tattoo Branding

out some systematic marking which tallies with the breeders' flock book. [W. J. M.]

Earnest, a sum of money given to signify the conclusion of a bargain. The rule of the Roman law was that, in a sale, where the purchaser failed to implement his bargain he forfeited the earnest, while the seller on failure repaid the deposit and as much again. This rule of law at one time obtained here, but is long since obsolete, only the deposit being returned in such a case. It is, however, still the law that, as a general rule. the deposit is forfeited if the party who deposited it fail to implement his bargain. In England the giving of a sum by way of earnest is one of the modes whereby the *necessity for writing to constitute* a binding sale of goods of the value of £10 or upwards is obviated (Sale o Goods Act, s. 4). Where the sum given is insignificant in proportion to the value of the transaction, it is not computed to account of the consideration, and in such a case is, in Scotland, sometimes called *dead* earnest. Otherwise the earnest is computed to account of the consideration on completion of the transaction. In Scotland the giving of *arles* is not indispensable unless notorious local custom demands it. In such a case there is room for resiling until it is given, but once the bargain has been sealed by the giving of the earnest, its return will not entitle parties to resile. But while the giving of earnest may point to a concluded bargain, it is ineffectual to validate a contract otherwise voidable. Thus where writing is necessary to the completion of a valid contract, *e.g. to the constitution of* a lease for a term of years, the want of it could not be supplied by the giving of earnest. [D. B.]

Earthing up.—Earthing up is generally confined to covering up of potatoes with mould, though sometimes cabbages are lightly treated in this manner; and in some districts swede turnips are covered with mould to prevent injury from frost, which is a form of winter storage without taking up the plant. Earthing up can be performed by an ordinary hand hoe, and the best work may be done in this way; it is, however, slow, and single- or double-breasted ploughs are more commonly used. The single plough is not so effective as the double-breasted one, as it does not run so steadily, nor work so cleanly. The double-breasted plough does excellent work, but it is essential that the share be chisel or square pointed or it will not run *steadily. Since the introduction of the sickle*tine cultivator, moulding up has largely been done with two or more double breasts attached to the frame, and this is most economical. When on a frame the share points need not be chisel-pointed, as one helps to keep the other steady. See also RIDGING. [W. J. M.]

Earthnut, or **Peanut** (*Arachis hypogæa*), is a yellow-flowered herbaceous plant of the Tropics. It belongs to the nat. ord. Leguminosæ, and on light sandy soils is extensively cultivated for its large yield of oily seeds; indeed in tropical agriculture Earthnut is one of the most important crops. The only part of the plant with which we in Britain are familiar is the fruit and seed, sold in the shops as peanuts. The stem is 2 ft. high, and bears leaves compounded of four leaflets arranged as two



Earthnut (*Arachis hypogæa*)

pairs. The flowers are stalkless and clustered in the leaf axils, but after fertilization, when the corolla falls off, a flower-stalk forms for a special purpose, viz. fruit burial.

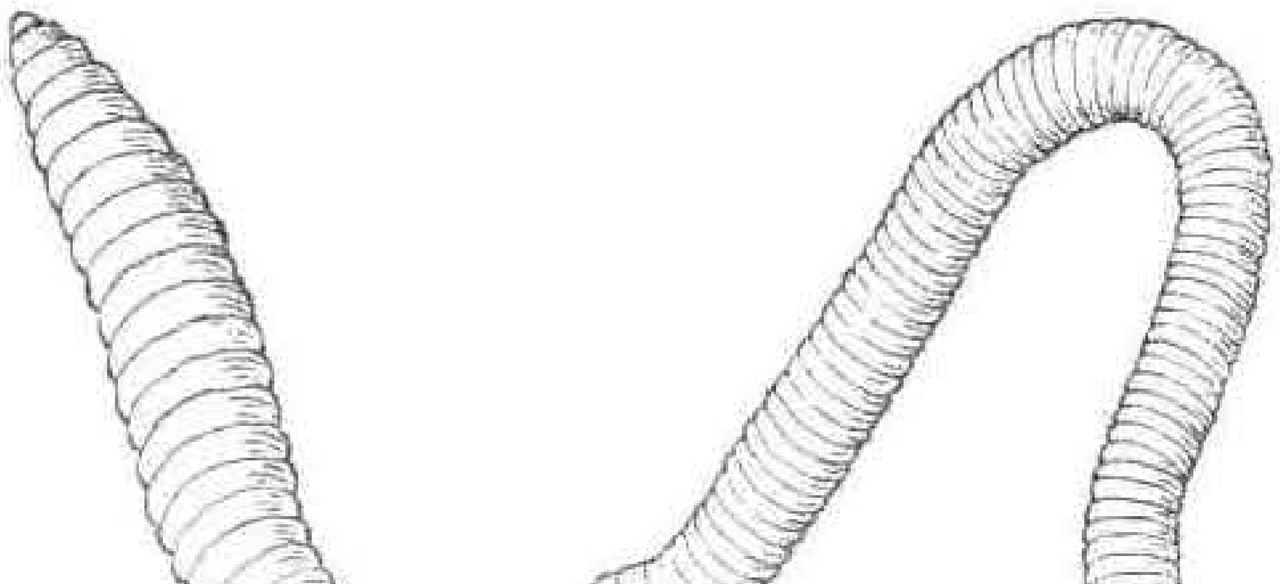
This flower-stalk lengthens to 2 or 3 in., and in growing bends down under the influence of gravity (*geotropism*), ultimately forcing the fruit as yet young into the sandy ground. There the young fruit enlarges into a yellowish wrinkled seedcase, slightly constricted in the middle, and *containing* two reddish-brown seeds larger than peas. This is the fruit which is imported and sold as Peanut. For fruit ripening, burial is essential; without it the flower remains immature and withers away.

The value of Peanut seed depends not only on its oily content, equal to half the weight of the whole seed, but also on the presence of albuminoids to the extent of one quarter of the seed weight. The seeds are extensively used for oil production, and this oil forms an excellent substitute for that of the Olive. For oil making,

large quantities of Earthnut fruits are imported into France and other countries. But the herbage is also valuable, for cattle devour it greedily, and in some of our colonies Earthnut might with advantage be cultivated for forage. Fruit burial occurs also in *Voandezia subterranea* of tropical Africa. There the negroes cultivate this earthnut, and use its seeds as food. The Earthnut, or Pignut, of our own country is the tuber of the common umbelliferous plant *Bunium flexuosum*. [A. N. M'A.]

Earthnut Cake. See GROUNDNUT CAKE.

Earthworm, a popular name for several different kinds of terrestrial Chætopods, or



Earthworm

bristle-bearing worms, belonging to the section Oligochæta. In Britain there are fully a score of different species, belonging to various genera, Lumbricus, Eisenia, &c. Many genera of similar habits are found nearly all over the world, up to an elevation of 10,000 ft. The number of individuals is greater in the temperate zone, but some parts of the Tropics are very rich in species. Earthworms are absent altogether from some of the arid regions of Africa.

The Earthworm is cylindrical in form, flattened at the hind end, and bears four pairs of setæ on each segment of the body. It can neither hear nor see, but it is sensitive to light and to vibrations. It is hermaphrodite; the reproductive organs lie in front of the swollen 'clitellum' or saddle towards the anterior end of the body. It is preyed upon by centipedes, moles, and many birds.

The Earthworm makes a burrow several inches deep, and usually enlarged at the end into a chamber lined with leaves, pine needles, and the like. In this burrow it passes the day, and even at night often keeps a part of the body within it, and forages in a circle all round. In very loose soil the burrow is made simply by boring, but in most cases the Earthworm eats its way through the soil, which is thus finely triturated in the very muscular gizzard, mingled with the digestive secretions, and expelled, sometimes within, but more usually at the mouth of the burrow, in the form of the familiar castings. The Earthworm obtains a part of its food from the organic particles in the soil, but in the main it feeds on leaves and decaying vegetable matter. Growing plants—especially, it is said, onions and celery—are undoubtedly also taken toll of to some extent, but the damage done is insignificant compared with the advantages gained from the Earthworm's presence in the soil. These advantages have long been recognized. More than a century ago Gilbert White wrote: 'Worms seem to be the great promoters of vegetation, which would proceed but lamely without them, by boring, perforating, and loosening the soil, and rendering it pervious to rains and the fibres of plants, by drawing straws and stalks of all kinds into it, and most of all by throwing up such infinite numbers of lumps of earth. The earth without worms would soon become cold, hardbound, and void of fermentation, and consequently sterile.' But it required the wonderful series of observations and calculations carried on by Darwin throughout many years to enable us to form an idea of the magnitude of the Earthworm's work. Darwin—agreeing in this with Hensen—estimated the number of earthworms in an acre of garden ground at 53,000, and the amount of soil brought up by them and deposited, in a finely pulverized state, at 10 tons annually. On a marked-out area of common land 700 ft. above sea level, the castings, which were fairly evenly distributed over the whole surface, were collected for a year, and, when well dried, were found to amount to 7·453 lb. per square yard, or 16 tons per acre, which would be sufficient, in the course of ten years, to cover the whole surface with a uniform layer of fine mould 1·429 in. in thickness. A field, ploughed and harrowed, and left to become pasture, in 1841 was covered with small and large flints, 'some of them half as large as a child's head'. The smaller stones had disappeared in a few years, and in thirty years (1871) 'a horse could gallop over the compact turf from end to end of the field and not strike its hoof against a single stone'. Many other observations were made in regard to the burying of ancient tessellated pavements, the drifting of castings, the germinations of seeds in the burrows. In regard to this last point, a recent American writer has made a special study, which leads him to the conclusion that, by their habit of dragging the seeds of trees into the heap of vegetable mould and soil at the mouth of the burrows to eat off the 'wings', earthworms may play a not inconsiderable part in the propagation of some kinds of forest trees.

If we take into account all the processes due to the activities of the Earthworm—the bringing up of finely sifted mould; the burying of decaying and half-digested leaves in a condition favourable to the generation of humus acids; the tunnelling of the ground by the burrows, which makes it easily penetrated by air, raindrops, and the roots of plants; the slow but ceaseless movement caused by the collapsing of the old burrows, and the constant drifting of the fine surface mould from the slopes to the valleys,—and if we consider for how long a time they have been going on, we shall have little difficulty in agreeing with Darwin's own conclusion: 'It may be doubted whether there are many other animals which have played so important a part in the history of the world as have these lowly organized creatures'. [J. A. T.]

Earwigs. See FORFICULA AURICULARIA.

Easements. See WATER RIGHTS, ROAD, and SERVITUDES.

Eaves.—The eaves are that part of the roof which projects over the sides, and also in some cases the ends of the walls of a building. When thatch was the accepted roof-covering material, the eaves of necessity were a little more conspicuous than they are nowadays. Slate and tile have now taken the place of thatch, and neither admits of being carried more than a few inches beyond the face of the wall. We can, of course, project the eaves for a foot or two if we wish, but this means special fitting up of the roof for that purpose, and more or less exposure of the supporting woodwork to the elements. Eaves which are too short fail to throw rainwater clear of the face of the wall. When the wind is not blowing directly against either side of the house, the drippings from a thatched roof will fall clear of the wall. But the least puff or eddy of the wind will suffice to throw the drip from an ordinary slate or tile roof against the wall. This is not only injurious to the face of the wall, but it is also detrimental to the foundations of the building. To guard against this, eaves gutters (spouts as they are sometimes termed) were introduced in connection with narrow eaves. Perhaps it was more with a view to obviate the discomfort that follow dripping eaves that first led to their introduction. Indeed there should be no buildings on the farm without these finishings to roofs. The discomfort both to men and animals of dripping eaves, and the puddles these cause in doorways, and in yards in general, are sufficient to justify the outlay which the fitting up of these necessitates. Cast-iron eaves gutters with drop pipes or conductors are well adapted for country use. They are strong, and are easy to fit up. Both are made in 6-ft. lengths, and there are various supplementary pieces. Each gutter has a socket or depression at one end, into which another pipe end is laid bedded in

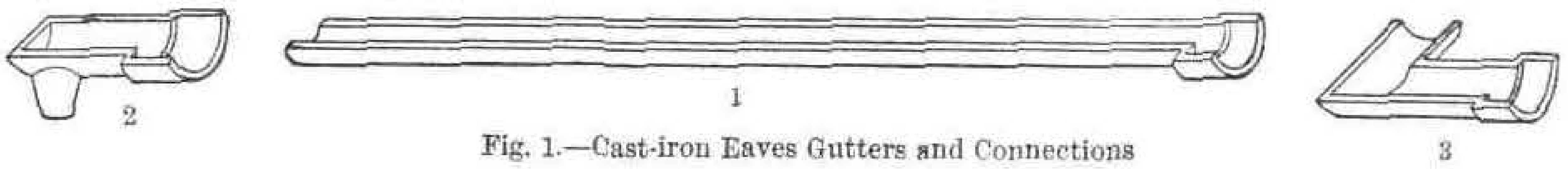


Fig. 1.—Cast-iron Eaves Gutters and Connections

1, Length (2, 3, 4, or 6 ft.); 2, Drop end; 3, Angle, left hand.

putty. The two pieces are held tightly together by means of a small screw bolt and nut. Each length rests on three hooks 2 ft. apart fastened to the roofing boards. In windy districts the gutters are secured to the hooks with copper wire. These hooks are nearly always galvanized. We advocate the gutters and conductors being similarly dealt with, because in their case paint is seldom forthcoming. Usually, however, their own weight serves to keep the gutters at rest on the hooks. The various pieces shown in the accompanying figures give an idea of how easily eaves gutters can be fitted and repaired. It is usual to strengthen the gutters by means of a bead or thickened part at the edges. It is not usual, however, for the discharging shoe to have a cleaning door. Lead was at one time the material for these gutters. Farm buildings had little acquaintance with lead, however. Zinc gutters are in use in some districts. [R. H.]

Ebony is the name applied to the dark-brown or black heartwood of trees belonging to the genus Diospyros of the nat. order Ebenaceæ, indigenous to most tropical and subtropical countries. In all the species of this genus the dark-coloured heartwood is very hard, heavy, tough, durable, and easily polished, although the broad, light-coloured sapwood is of no commercial value. Hence the marketable portion of the trunks of large trees girthing 8 to 10 ft. or more becomes much reduced when the useless sapwood is cut away. The best and blackest ebony, prized for inlaying, veneering in cabinet-work, pianoforte keys, knife handles, &c., is that furnished by *D. Ebenum*, abundant in southern India and Ceylon, *D. reticulata* of the Mauritius, and *D. hirsuta* of Ceylon ('Calamander Wood'); while the next best in quality is that yielded by the wild Persimmon-tree, *D. melanoxylon*, common in India, Burma, and Senegal, a large tree with a dark chocolate-coloured heartwood, which blackens gradually in course of time, though without ever acquiring the jet-like, ebon-black colour of *D. Ebenum*. Other species of still less value are the *D. Ebenaster* of Ceylon, the *D. tomentosa* of northern Bengal, the

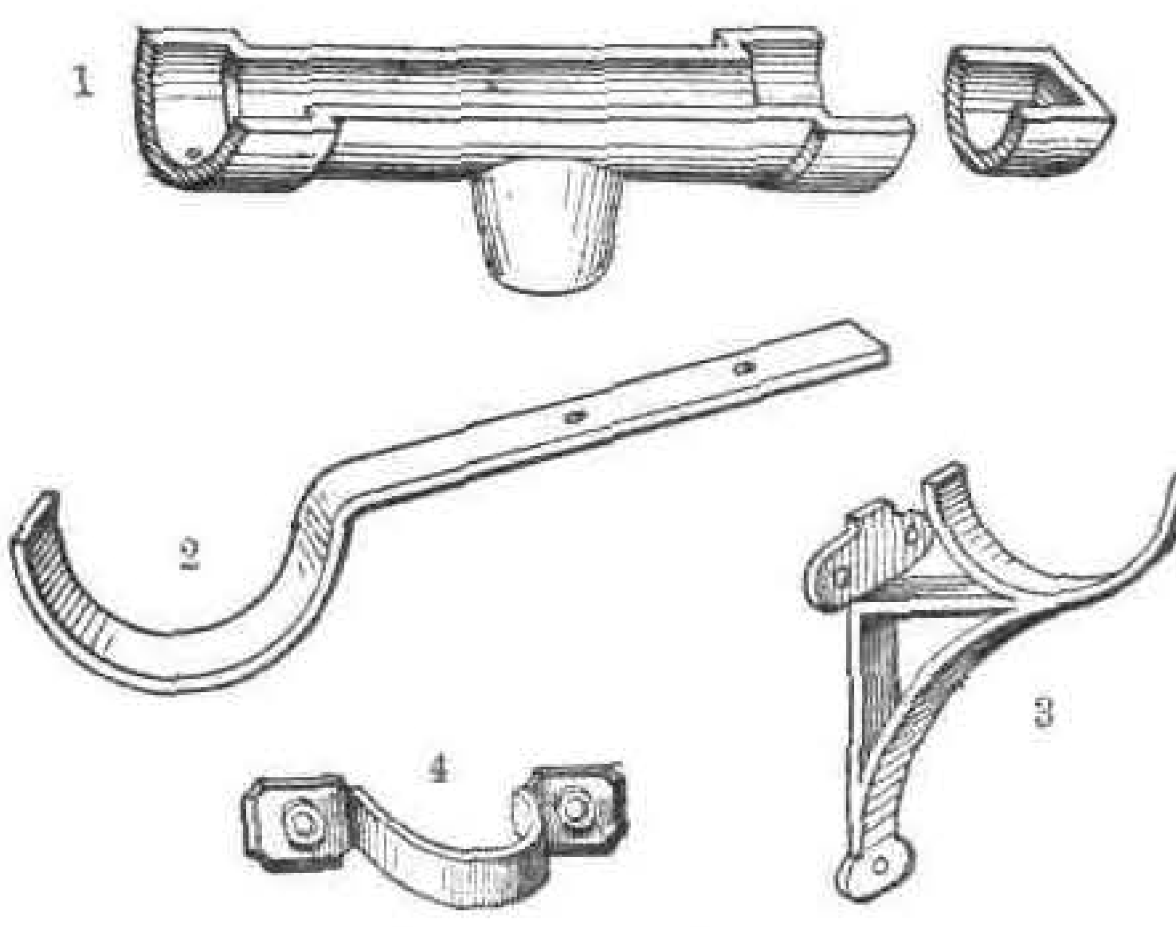


Fig 2.—Eaves Gutters

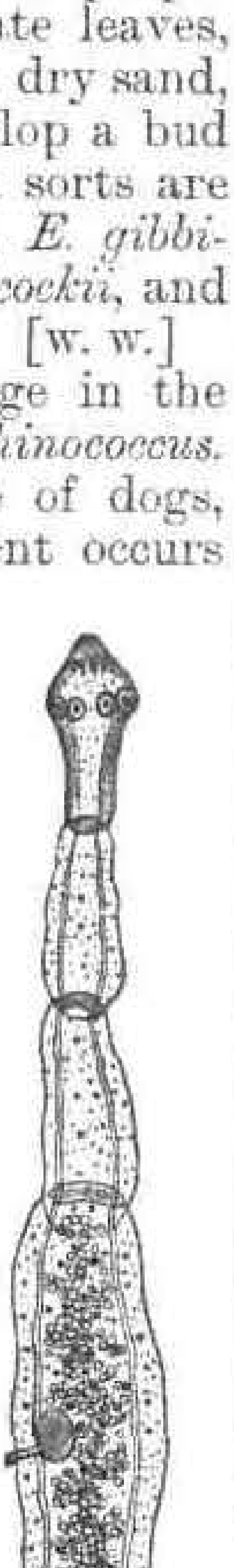
1, Nozzle piece; 2, 3, Supporting brackets; 4, Ear band or clip

D. montana scattered throughout the Indian hill ranges, the Texas Persimmon (*D. texana*), and the 'green ebony' from the Mediterranean Date Plum (*D. Lotus*). The ebony of commerce also comprises the heartwood of the *Maba Ebenus* of the Moluccas, the African ebony from species of *Euclea*, the 'brown or red ebony' of Crete from *Ebenus cretica*, and 'West Indian ebony' from *Brya* (*Pterocarpus*) *Ebenus*, while the black Indian rosewood or Bombay blackwood of *Dalbergia*

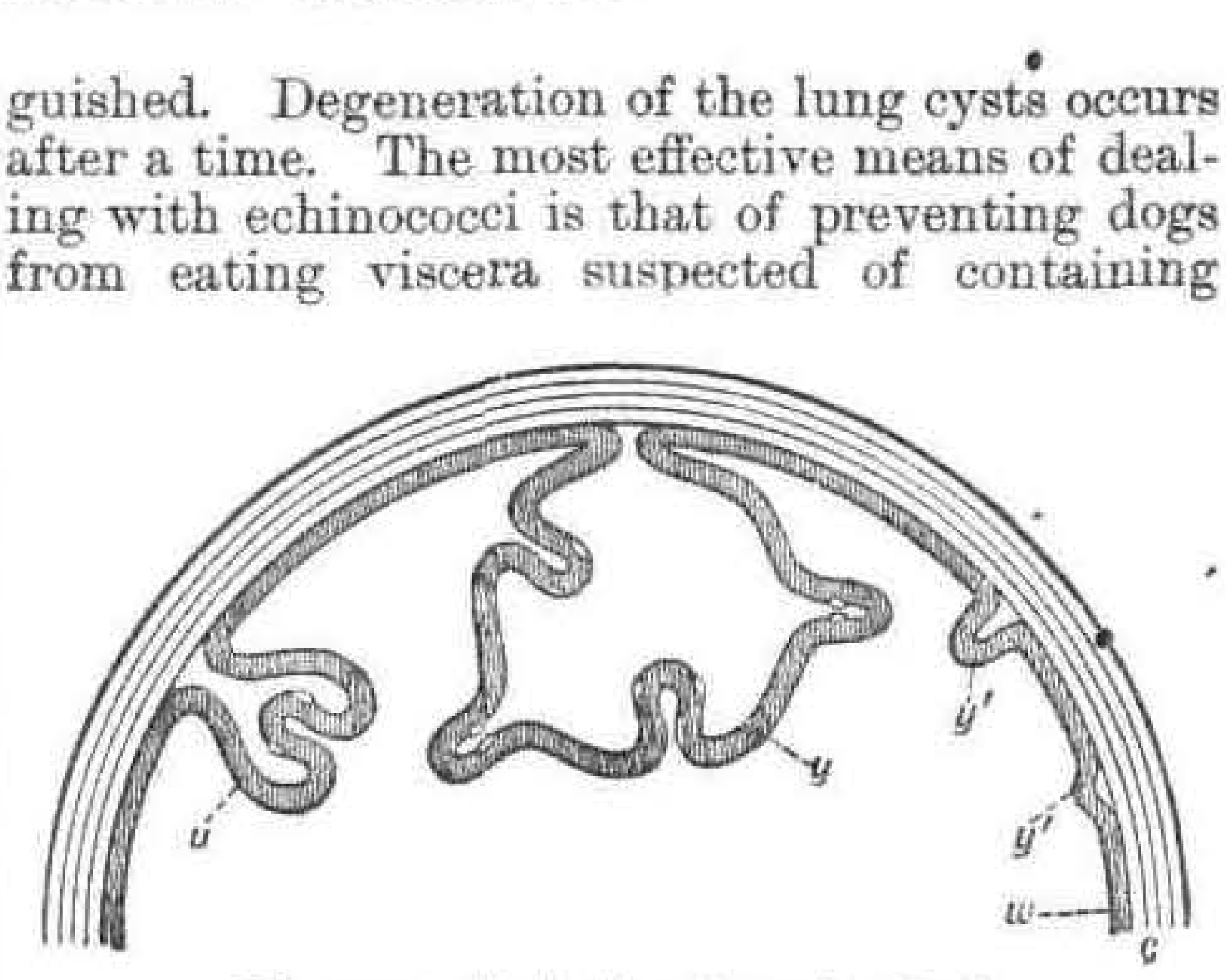
latifolia is a wood of a similar class. There are also many imitations, such as the stained yew sold as 'German ebony'. [J. N.]

Echeveria.—This genus is now included in Cotyledon, the Navelwort family (order Crassulaceæ). It is characterized by fleshy leaves, arranged in a dense rosette usually on a short stem, and flowers in spikes. Some of the species are grown for summer bedding, and others are included with rockery plants, while the House Leek (*E. sempervivum*) is a very familiar plant on the roofs and walls of cottagers' dwellings. They are all easy to grow, and may be propagated from offsets or from the separate leaves, which should be pulled off and laid on dry sand, where they will form roots and develop a bud at the base. The best of the garden sorts are *E. agavoides*, *E. coccinea*, *E. fulgens*, *E. gibbiflora*, and its variety *metallica*, *E. Peacockii*, and *E. secunda*. [W. W.]

Echinococcus, the asexual stage in the life-history of the tapeworm *Tænia echinococcus*. This worm is found in the intestine of dogs, wolves, and jackals, and when present occurs in large numbers. It is a small worm, being about ⅜ in. long, and consisting of four segments, only the last of which is mature at one time. At the anterior end there are four suckers and two circlets of minute hooks, by means of which the worm adheres securely to the intestinal wall. The asexual stage, to which alone in the strict sense the term 'echinococcus' is applied, occurs in various organs of herbivorous animals, carnivora, monkeys; and in places where man associates intimately with dogs, *e.g.* Iceland or Victoria, he also is not infrequently infected. Echinococcus occurs most commonly in ruminants and pigs. The distinctive peculiarity of the 'echinococcus' bladder-worm (see art. CESTODES, BLADDER-WORMS) is the fact that internally from its walls secondary and even tertiary bladders may bud off, from each of which a large number of heads are formed. When the bladder is swallowed by a dog or wolf, each of these heads develops into a *Tænia echinococcus* in the intestine. Echinococcus bladders may reach a considerable size, so as to be several inches in diameter; they occur most frequently in the liver, but may invade lungs, kidneys, spleen, heart, muscles, or even bones. The same animal may be infected in several organs. When the liver is infected its volume is so enlarged that the adjacent organs are displaced or compressed, the curvature of the diaphragm is increased, the lungs are diminished in volume, and peritoneal adhesions may occur. The health of infected animals, especially cattle and sheep, is very generally more or less seriously impaired, although death is not common. In the case of infection of the lungs the symptoms bear some resemblance to those of pleuropneumonia or tuberculosis, but on investigation are readily distinguished. Degeneration of the lung cysts occurs after a time. The most effective means of dealing with echinococci is that of preventing dogs from eating viscera suspected of containing cysts, and of ridding them of *Tænia echinococcus* by periodic anthelminth purgatives. Animals seriously infected should be slaughtered. [J. R.]



Tænia Echinococcus (magnified)



Diagrammatic Section through a Cyst

w, Wall; *c*, Cuticle; *y*, Brood-capsule; *y'*, The same in an incipient state (after Boas).

Echinops, a large genus of annual or perennial Composites popularly known as globe thistles, the flower-heads, which are globose, being composed of prickly scales and bristles, among which are the blue or white florets. Some of the species are grown as hardy border plants, and as they thrive in any garden soil, grow quickly to a height of 3 to 5 ft., and their pinnatifid leaves are large and decorative, while the flower-heads are bold and attractive in appearance, they are excellent plants for the purpose. The annuals are raised from seeds sown in spring, the perennials are easily multiplied by division. The best of them is *E. ruthenicus*, from South Russia, which has steel-blue flower-heads. Others that are grown are *E. bannaticus*, blue; *E. commutatus*, white; *E. Ritro*, blue; and *E. sphærocephalus*, pale-blue. [W. W.]

Echium, a genus of Boragewort consisting of some twenty species, some herbaceous, others, particularly several that grow in Tenerife, forming large woody shrubs, with long simple leaves, and large panicles of usually blue flowers. The Viper's Bugloss (*E. vulgare*) is one of the prettiest of British weeds, which spreads over waste ground. It grows 1 to 3 ft. high, producing from June to August cymes of blue flowers, red-purple when in bud. They are all easily raised from seeds. In the Scilly Islands some of the species from the Canary Islands grow rampantly, and when in flower they are magnificent. See also VIPER'S BUGLOSS. [W. W.]

Echocerus cornutus (the Broad-horned Flour Beetle), a small brown beetle, about ⅙ in. long, which is frequently a veritable pest in bakeries in Europe and America. It also feeds on stored wheat, maize, barley, meal, and bread in outhouses and stores. It is characterized by its large and conspicuous broad horns, seen at the base of the mandibles in the male. The eggs are laid in the meal, flour, or grain, and the six-legged larvæ also feed upon it. With warmth they breed all the year round. Attacked materials are best treated by exposing

them to the fumes of bisulphide of carbon or by having them kiln-dried. [F. V. T.]

Eclampsia.—Eclampsia is the name given to a reflex nervous affection or fit to which female animals are subject, at or soon after parturition. Great excitability, denoted by wild and staring eyes, head erect or extended backwards, and switching of the tail, paddling of the hind feet, protrusion of the tongue, exalted sensation in the skin, rapid breathing, and a full strong pulse are the symptoms. Sudden cessation of milk production is an invariable symptom, and in cows there is more or less dementia and a disposition to kick, and even to gnaw the manger. Sows and bitches called upon to rear too many young are attacked later, when the greatest demand is made upon the lacteal glands, and their behaviour is very much the same, being modified only by their usual general habits. Bloodletting affords immediate relief, and suitable purgatives bring about the desired result, only in a longer period. Direct sedatives, as chloral hydrate, are most effective in allaying the intense excitement. Where the cause is due to excessive demands upon the udder, the number of young must be immediately reduced, and generous feeding adopted, but not too suddenly. [H. L.]

Eczema, a disease of the skin, characterized by eruptions of vesicles of varying size, and of most frequent occurrence upon the parts least covered by hair. Dermatologists make many distinctions between the varieties of eczema, but for our purpose it will be sufficient to distinguish between the simple or acute and the chronic. The causes in animals are generally to be traced to errors in feeding, this being the more easily discovered when a number of cattle in one herd become affected at the same time. Sour bran or fermented meals, frostbitten roots or other damaged forage, have been proved in many instances to produce eczema. The skin appears to suffer in an attempt to rid the system of some effete material which is ordinarily disposed of by the kidneys and bowels, and an appeal to those organs is often found to be the best treatment, local applications being merely palliative. The size of the vesicles and of the patches bears some relation to the size and species of animal affected, so that we find large bladders, easily identified on the ox, and such tiny pinpoints upon little pigs and dogs that we can only determine the nature of the eruption in many cases by familiarity with it as a scab, when the vesicles have broken and coalesced, which is the usual course of the malady. Grass mange so called is a form of eczema, and so is the eruption at the back of the knees and in front of the hocks of horses; and the malady known as grease is eczematous in its origin, although having but little resemblance to it in its later development (see GREASE). Mallenders and sallenders are examples of chronic eczema, but such a condition may affect other parts, and favours such as have harness or gear bearing upon them. The degree of irritation produced by eczema differs very greatly, some animals rubbing themselves raw and doing serious damage to the skin, while others appear not to notice it. Dogs, owing to their gross habits of feeding upon offal, and pigs fed on slaughter-house refuse, suffer severely. *Treatment* consists in change of food; a preliminary purgative, and the administration of ant-acids as soda and potash, or of dilute mineral acids with stomachic correctives such as calumba and gentian, and small alterative doses of salts. A wash of bicarbonate of potash or an emollient of carron oil may be used to allay irritation and prevent rubbing. [H. L.]

Edam Cheese—so-called because the town of that name has long been the chief emporium for dairy products in northern Holland—has been widely known in western Europe for many years, and more so perhaps in the past than now. More to the export energy of Dutchmen, perhaps, than to any commanding superiority of the cheese, does it owe whatever publicity has surrounded it in bygone or in modern days. Much, too, is owing to the economic fact that normal production of cheese in Friesland was greater than was wanted for home use. There were openings for it to be found in England, France, and elsewhere, at prices that were attractive; they were diligently sought for, and intelligently cultivated, with an eye to trade.

Dutch cheese is generally a trusty if commonplace article of diet, designed for men used to manual labour — men whose digestive organs required nutritious and substantial food, and whose means were limited to the purchase of something cheap and good. On these foundations Dutch cheese became in a way possessed of a special kind of popularity wholly its own. This was accentuated by the harlequin-like colouring done in triangles, or other patterns, on the rind of the cheese. A number of these coloured, 'cannon-ball'-shaped cheeses, brilliant in yellow and red, and even blue, presented a sight that was unique.

Edam cheeses are spherical in shape, and are generally small, weighing from 2 to 5 or 6 lb., and occasionally a few, weighing about 12 lb. each, are made to meet a known demand for such larger ones. The smaller sizes met requirements of labouring men's households. The cheeses are made at a somewhat high temperature, which ranges from 86° to 94° F. between the depth of winter and the height of summer, during the fermentative process of coagulation. The escape of whey is expedited by pressure. In summer-time, or in hot weather, a little salt is put into the centre of each ball of curd when it is being packed into the mould. Further necessary salting is done by outside application.

These well-made cheeses, firm and solid in texture, will keep in good condition two or three years, if reasonably treated in storage. Owing to this good-keeping quality they are in demand for exportation to tropical and subtropical countries, such as China and Australia, though less so now than was formerly the case, and especially so to the Antipodes, where nowadays good cheese is somewhat extensively made. Owing to the dilatory ripening of Edam cheese it is not so easily digestible an item in dietary as are the earlier ripening full-milk kinds of cheese. A sort of Dutch Stilton is made from

double-cream milk, but the mode of making is not conducive to such mellowness of texture as the Stilton possesses. [J. P. S.]

Edgings.—Plants that are used to form margins to borders and flower beds are known as edgings. The most frequently used is the common Box. Other plants suitable for the purpose are *Euonymus radicans variegata*, Ivy, Lavender, Heaths, Pinks, Thrift, Aubrietia, Periwinkle, Gentian, Candytuft, and Rosemary. These are all better than stone or tile edgings. [W. W.]

Education, Agricultural. — Systematized education in agriculture in Great Britain is the product of little more than the past hundred years, though earlier even than the middle of the 18th century advanced minds were awakening to the fact that the most hopeful path to agricultural improvement lay along the line of organized instruction. So far as can be ascertained, the first distinct course of academic lectures on agricultural science was delivered by William Cullen, professor of chemistry in the University of Edinburgh, in 1768, and these discourses were subsequently published in London under the title, The Substance of Nine Lectures on Vegetation and Agriculture. Another professor in the same university, namely John Walker, who filled the chair of Natural History, gave a course of lectures on agriculture in 1788, and these probably formed the foundation for his volume of Essays on Natural History and Rural Economy, published in London in 1812. Doubtless owing to the stimulus imparted by the pioneer work of these two men, Sir William Pulteney on July 7, 1790, endowed a chair of Agriculture and Rural Economy with £50 a year; and thus the University of Edinburgh has the honour of being associated with the oldest definite professorship of agriculture in the United Kingdom. The first occupant of this chair was William Coventry, who held it till 1831. At first he lectured annually, his course in some cases extending to as many as 140 lectures, but latterly he lectured only in alternate years, advising those who desired to attend in the intervening years to take up chemistry and botany and wait till he was ready to resume his class. Coventry was examined by the Universities Commission of 1830, and gave it in evidence that his classes numbered from thirty to seventy-eight. But apparently he failed to convince the Commission that his intermittent instruction was in the best interests of the subject, for in their Report they recommended the abolition of the chair, 'unless a class could be provided for and taught regularly'. Coventry appears to have been much in request in regard to agricultural valuations and works of land reclamation and improvement, and he wrote extensively on live stock, systems of cropping, and rural economy generally. He resigned his appointment in 1831, being succeeded by David Low, who held the chair till 1854. During that period his classes are said to have been attended annually by seventy to ninety students. Low was a prolific and attractive writer, his work on the Breeds of Domesticated Animals of the British Isles, which appeared in 1842, being characterized by great thoroughness and lucidity. In 1833 he induced the Chancellor of the Exchequer to give £300 a year towards the cost of providing an educational museum of rural economy in the university; and with this grant, supplemented by a contribution from the Reid fund, and aided out of his private income, he commissioned an artist (Shiels) to visit various countries and portray on canvas the best examples of the various breeds of live stock. Altogether £3000 was expended on the collection, of which £1500 came from Government, £300 from the Reid fund, and £1200 from Professor Low himself.

Low's successor was John Wilson, who had held the principalship of the Royal Agricultural College at Cirencester from 1846 to 1850, when he resigned in consequence of some friction between himself and the governing body, owing to his desire to put all the grassland of the college farm under tillage. His views on Scottish farming did not altogether harmonize with those of northern authorities, but that he was successful as a teacher is proved by the success of many of his old students. His merits were widely recognized by foreign governments, and his greatest literary work, entitled Our Farm Crops, which appeared in 1860, is deservedly acknowledged to be a masterpiece on the subject. In 1868 Professor Wilson induced the Highland and Agricultural Society of Scotland and the Government to provide an additional endowment of £150 a year each, and subsequently the Society associated a series of bursaries with the Chair. Professor Wilson resigned in 1885, when he was succeeded by an old pupil, Professor Wallace.

Six years after the foundation of the chair in Edinburgh, Professor Sibthorp of Oxford gave a benefaction for the establishment of a professorship of rural economy in the University of Oxford, and until 1884 it appears to have been held conjointly with the Chair of Botany. Apparently its influence on agriculture was negligible till 1884, when it was separated from the Chair of Botany, being held successively by Sir J. Henry Gilbert and Professor Warington. In 1906 this professorship was reconstituted and re-endowed, and now acts as the centre of an active university department of agriculture and rural economy.

These two professorships of agriculture and rural economy were all that the country possessed till 1842, when the idea of founding the Royal Agricultural College took hold of certain landowners in the south-west of England. It received its first charter in 1845, and a supplementary one in 1849. Fortunate in its staff (Voelcker, Brown, Coleman, &c.), it has attracted to its classrooms a large proportion of the young landlords, farmers, and land-agents of England, and in this way it has had an important influence on the agriculture of the country.

A private institution, manifestly modelled on the lines of the Royal Agricultural College, was started at Downton in 1880. The class of student was much the same at the two centres. Downton, too, was fortunate in its staff (Wrightson, Fream, Munro, &c.), but unfortunately it ceased

to exist in 1907. In 1882 the teaching of the science of agriculture was started under Government auspices at South Kensington, but it appears to have been attended with little success, and was abandoned in 1899.

The school of agriculture at Aspatria in Cumberland, founded by the late Dr. Webb in 1874, is entirely of a private character, and aims with much success at preparing youths for farming at home and in the Colonies. Reference must also be made to another private institution—the Colonial College at Hollesley Bay in Suffolk—whose object was to train young Englishmen for a colonial life, but which suspended operations in 1903.

In enumerating the older educational agencies of an agricultural character, mention must be made of the part played by three corporate bodies. The Royal Agricultural Society of England in 1868 instituted a searching examination in agriculture and the cognate sciences, granting certificates and money prizes to successful candidates. It also, in 1874 and subsequently, offered a number of junior scholarships to boys between the ages of fourteen and eighteen, its object being to give successful candidates the opportunity of prosecuting the study of agriculture on a farm or at a college. A fair amount of success attended both of these schemes, but they have since been merged in a joint scheme with the Highland and Agricultural Society of Scotland. This Society, like the Royal, formerly conducted an independent examination, and granted a diploma and certificates. In 1898-9 the two societies evolved a joint scheme of examination in agriculture, the diploma granted (in 1900 for the first time) being known as the National Diploma in Agriculture. Besides the two societies chiefly concerned, the Examination Board contains representatives of the Scotch Education Department and of the Board of Agriculture and Fisheries. In 1897 a similar examination in dairying had been started, the National Agricultural Examination Board controlling both examinations.

The Surveyors' Institution has for some years annually conducted examinations in agriculture and rural economy (*a*) for admission to the Institution as Professional Associates (P.A.S.I.), and (*b*) for the Fellowship of the Institution (F.S.I.).

Finally, so far as formal education and examination in agriculture before 1888 is concerned, mention may be made of instruction in the 'Principles of Agriculture' conducted by teachers in local centres, acting in conjunction with the old Science and Art Department, who held an annual examination, on the results of which grants from the national exchequer were awarded. This system was started in 1875 and continued till 1903, when the syllabus was revised and the subject changed to 'Agricultural Science and Rural Economy'. Under the old regime the teaching was essentially bookish, and largely partook of the nature of cram. Now, however, it is much more practical and experimental, and annually attracts throughout England some hundreds of youths who might not otherwise be reached.

So far attention has been exclusively directed to agricultural education of a classroom or formal type, but in the 18th century and early in the 19th, stimulus of interest and the diffusion of knowledge were largely secured through the agency of annual gatherings on the farms of leading agriculturists, or by means of agricultural treatises. In 1778 the celebrated Coke of Holkham, in Norfolk, organized an annual meeting on the occasion of his sheep-shearings, the main purpose of which was the exchange of ideas between the agriculturists who were thus brought together. Coke's example was imitated by others, notably by the Duke of Bedford, whose gatherings at Woburn became the rallying-point for the progressive agriculturists of the time. Farther north, George Cully of Fowberry Tower conducted experiments of various kinds, and 'crowds used to visit his farms to see his experiments, which made an epoch in the agricultural history of Northumberland'. In their report to the Board of Agriculture in 1805, Cully and Bailey thus express themselves: 'Nothing would tend so much towards the perfection of agriculture in all its branches as public farms in every county conducted by proper persons. . . . A farm of this kind would not only be a school where youth might be instructed in agriculture, but even experienced farmers might often visit it with advantage.' About the same time the second President of the Board of Agriculture is found to be strongly urging the establishment of a national experimental farm, to be run on an annual subsidy of £500. He also eloquently pleaded for the inclusion of agriculture amongst the subjects taught at public schools and at the universities of Oxford and Cambridge. Organized diffusion of knowledge was undertaken by the Honourable Society of Improvers in Agriculture, founded in Scotland in 1723, and which in 1743 was pleading for the provision of facilities for agricultural education and research; by the Bath and West of England Society, established in 1777; by the Highland and Agricultural Society of Scotland (1784); by the Smithfield Club (1793); and more recently by the Royal Agricultural Society of England (1838). Of individual writers none was so productive as Arthur Young, the first secretary of the Board of Agriculture (1793). In the same decade Lord Dundonald was educating the public to a proper appreciation of the close connection that exists between agriculture and chemistry. This he did through his two works, The Principles of Chemistry applied to the Improvement of Agriculture, and A Treatise showing the intimate connection between Agriculture and Chemistry. It was also during the closing years of the same century that Sir Humphry Davy was engaged on his classic researches in scientific agriculture, which attracted so much popular attention that in 1802 he began the series of lectures before the Board of Agriculture, which were continued annually till 1812. Subsequently (1813) these lectures were epitomized in the famous textbook, Elements of Agricultural Chemistry, the influence of which on farming practice can hardly be overestimated.

The year 1888 may be said to mark the begin-

ning of modern developments in agricultural and dairy education in this country. It was in that year that the Departmental Committee presided over by Sir Richard Paget reported in favour of State aid being given for the establishment of local centres for agricultural education. As a result, the Agricultural Department of the Privy Council expended £2930 in this direction in the year 1888-9 (£1630 in England and £1300 in Scotland), the only college to receive a grant (£200) being that of North Wales at Bangor, which may thus be regarded as the pioneer of the modern movement. In 1889 the Board of Agriculture was created, and to it was delegated the duty of developing higher agricultural education. The policy of the Board from the first has been to establish strong well-equipped agricultural colleges, or agricultural departments in universities or university colleges, round which county councils could group themselves, and to which they could look for support and guidance in their purely local schemes. In the first year of its existence (1889-90) the Board of Agriculture granted £4585, of which £2160 was allotted to thirteen different local bodies in England and Wales, the balance going to Scotland. In the following year (1890) a notable event happened that has had a far-reaching influence on technical, including agricultural, education in this country. In that year the Government introduced a Bill which had, for its ultimate effect, the suppression of a certain proportion of the licensed houses, and for the purpose of compensating the licence holders a fund had to be provided. The Bill, however, was abandoned, but the fund remained; and the idea having occurred to someone that it would be a good thing to endow technical education with the money, the Government adopted the suggestion; and so it came to pass that the county councils of England and Wales, together with the metropolitan and county boroughs, receive annually under the Local Taxation (Customs and Excise) Act of 1890, a sum that in the early years amounted to close on a million pounds, all of which was available for instruction in the application of science to industry. The sum total of the grant is annually determined by the amount of whisky consumed, and as the tastes of the country have of recent years been in the direction of greater temperance, the 'whisky money', as it is called, has been suffering a gradual diminution, but it still approaches three-quarters of a million, of which about half a million is allocated to the various English and Welsh county councils in proportion to their rateable value. Of this sum about £80,000 is applied to agricultural, as contrasted with other forms of technical education.

The last year in which Scottish institutions received financial aid for agricultural education through the Board of Agriculture was 1895-6. Subsequently such grants were paid through the Scotch Education Department, but the Board of Agriculture has to some extent continued to supervise experimental work in Scotland. Seeing that higher agricultural education in England and Scotland is administered by two distinct Government departments, it may be convenient to look at the two countries separately.

In England the sum distributed in aid of educational institutions giving instruction in agriculture, horticulture, and forestry in the year 1906-7 was £11,550, as compared with £10,550 in the previous year. This sum was distributed amongst twenty institutions, which may be grouped as follows:—

1. *Agricultural Colleges, and Agricultural Departments of Universities and Colleges.*—University College of North Wales, Bangor; University of Leeds; Armstrong College, Newcastle-on-Tyne; University College of Wales, Aberystwyth; University of Cambridge; University College, Reading; S.E. Agricultural College, Wye. At all these centres except Reading, students are prepared for a degree (B.Sc. or B.A.), and this also applies to Oxford. The full course extends to three years, but shorter and longer courses may also be arranged. At Bangor and Newcastle special facilities are provided for instruction in forestry, the Board contributing £250 a year for this purpose. All of them have farms, and all receive £200 a year on account of this addition to their equipment. The general grant in each case is £800. The Midland Agricultural and Dairy College practically comes into this group, but as it is not associated with a university it does not grant a degree, though it awards a diploma.

2. A second group is formed by more purely local institutions, giving instruction suitable for the sons of farmers, taking part in extension and demonstrational work, but not equipped for the highest forms of research. Certain of them are specialized institutions, like the British Dairy Institute at Reading, the Eastern Counties Dairy Institute at Ipswich, and the National Fruit and Cider Institute near Bristol. Besides these centres the group includes the Harper Adams Agricultural College in Salop, the College of Agriculture and Horticulture at Holmes Chapel, the Agricultural and Horticultural College at Uckfield, the Essex County Technical Laboratories at Chelmsford, and the Harris Institute at Preston. The grant in respect of these is usually £300, but in one case is £400, and in one case £150. Most of them have farms attached.

3. A third group is composed of what may be called farm institutes or winter schools, which receive a younger class of pupil, or which hold short courses of a more purely practical character. This comprises the Cumberland and Westmorland Farm School near Penrith, the Hampshire Farm School near Basing, and the Ridgmont Agricultural Institute in Bedfordshire.

The Royal Veterinary College has recently been made the recipient of a grant of £800 a year, but its work is hardly of the character that we are now considering.

It is estimated that at present about 1500 students are under instruction at the various colleges and schools enumerated above, and that about 35,000 are reached by means of extension lectures and local classes worked from the centre. Besides these twenty institutions in England and Wales receiving State aid through the Board of

Agriculture, there are others doing work in agriculture, horticulture, and forestry which for various reasons do not receive such grants, though they may receive public money from other sources, such as the Board of Education, the India Office, and the Office of Woods. The department of horticulture in the University College of Reading gives instruction of the highest character, and grants a diploma in horticulture.* The horticultural colleges at Swanley and Studley Royal give instruction to women in horticulture, poultry, and domestic economy, and attract large numbers. The station of the Royal Horticultural Society at Wisley aims at being a centre of the highest forms of research. The forestry department in the University of Oxford provides a three-years course, which qualifies for the Indian and Colonial Forest Services. The Government Forest School in the Forest of Dean receives young men of the woodman class, the education being largely practical. The agricultural colleges at Cirencester and Aspatria have already been referred to. A school, unique of its kind, is to be found at West Lavington, in the county of Wilts. It is an old foundation (the Dauntsey), and provides at a moderate cost a most excellent education in general subjects, combined with a considerable amount of specialized instruction in rural science. Agreeing to some extent with the Dauntsey school are the grammar school at Shepton Mallet and the school at Brewood. The county school at Barnard Castle has long had an agricultural form, and more recently the grammar school at Morpeth has developed in a similar direction.

General Grants in Aid of Educational Institutions, 1906-7.

Name of Institution.	Purpose of Grant.	Amount of Grant, 1906-7.	Date of Inauguration of Agricultural Instruction.
		£	
University College of North Wales, Bangor ...	Agricultural Instruction	800	1889
,, ,,	Farm	200	
,, ,,	Forestry	250	
University of Leeds	Agricultural Instruction	800	1891
,, ,,	Farm	300	
Armstrong College, Newcastle-on-Tyne ...	Agricultural Instruction	800	1891
,, ,,	Farm	200	
,, ,,	Forestry	250	
University College of Wales, Aberystwyth ...	Agricultural Instruction	800	1890
,, ,,	Farm	200	
Cambridge University	Agricultural Instruction	800	1893
,, ,,	Farm	200	
University College, Reading	Agricultural Instruction	800	1893
,, ,,	Farm	200	
South-Eastern Agricultural College, Wye ...	Agricultural Instruction	800	1894
,, ,,	Farm	200	
Midland Agricultural and Dairy College ...	Agricultural and Dairy Instruction ...	600	1895
,, ,,	Farm	200	
Harper Adams Agricultural College	Agricultural Instruction	400	1901
College of Agriculture and Horticulture, Holmes Chapel	,, ,,	250	1895
Agricultural and Horticultural College, Uckfield	,, ,,	250	1894
Essex County Technical Laboratories ...	,, ,,	200	1892
Harris Institute, Preston	,, ,,	150	1892
British Dairy Institute, Reading	Dairy Instruction	300	1896
Eastern Counties Dairy Institute, Ipswich ...	,, ,,	300	1889
Royal Veterinary College	Veterinary Instruction	800	—
National Fruit and Cider Institute	——	300	—
Cumberland and Westmorland Farm School	Agricultural and Dairy Instruction ...	100	1896
Hampshire Farm School	Agricultural Instruction	100	1900
Agricultural Institute, Ridgmont	,, ,,	100	1895

Two county councils in England (West Sussex and the Soke of Peterborough) do nothing for agricultural education, and a considerable number are unassociated with a collegiate centre. Of the latter, however, some do excellent work through the agency of county staffs, and this applies in a marked degree to Cornwall, Gloucester, Monmouth, Somerset, and Warwick.

Besides education in scientific agriculture, horticulture, dairying, farriery, poultry keeping, &c., many of the county councils provide facilities for instruction in the processes of agriculture. Such instruction is intended chiefly for young agricultural labourers, and where the teacher is thoroughly suitable the results are very satisfactory. The subjects chiefly taught are hedging, ditching, ploughing, and thatching; while others comprise pruning, grafting, budding, fruit packing, hop drying, basket and hurdle making, sheep flock management and shearing, milking, drilling, grass mowing, turnip and mangold thinning, harvesting and stacking.

A sketch of agricultural education in England and Wales would not be complete without a short account of the part played by the Board of Education.

Education in English schools is regulated by

the Act of 1902 and by the Code of 1904. Payment out of imperial funds through the Board of Education is dependent on the general character of the instruction, and on its suitability to the locality; that is to say, the old method of payment on 'specific subjects' is abolished, and a 'block' grant substituted. The county council is the local education authority, and it has the responsibility of seeing that the character of the instruction is appropriate to the future careers of the bulk of the pupils. In elementary schools boys may now be taught nature study (including the elementary botany of grasses, crops, trees), elementary entomology, beekeeping, &c. &c., handicraft and gardening; while girls may be instructed in dairying, domestic economy, &c. The addition of gardens to elementary schools has been a marked feature of recent developments, and the interest aroused through this agency amongst the pupils cannot fail to be of ultimate advantage to rural England.

In secondary schools, aided by the Board of Education, the aim is to give a thorough grounding in the fundamental sciences (botany, physics, chemistry, &c.), and, in the later stages of the course, to encourage the study of the application of these subjects to the industries of the country, including agriculture.

In evening schools, which are designed for youths at work during the day, a wide choice of subjects is permitted, including bookkeeping, dairying, gardening, and particularly 'agricultural science and rural economy', for which a comprehensive and well-graded syllabus has been prepared.

It is now possible, under the Robson Act, for boys and girls between eleven and thirteen years of age to obtain exemption from attendance at school at certain seasons. In this way such pupils may be usefully employed at light forms of work, *e.g.* fruit picking at busy seasons, and may thus be brought sooner into touch with practical country life.

The Board also encourages the training of country schoolmasters in special subjects, such as horticulture, entomology, poultry keeping, and nature study.

In Scotland the general scheme of education in rural economy agrees closely with that in England. The opening of continuation classes is encouraged by the Scotch Education Department, which, north of the Tweed, takes the place of the Board of Education. It cannot be said, however, that local education authorities have shown any great eagerness to open classes, the number of centres thus provided for in 1905–6 being only fifteen, with an aggregate attendance of 282 pupils. The grant paid on account of this work amounted to £122, 17*s.* 2*d.*

The highest form of education in rural economy is provided through three agricultural colleges, to whom the Scotch Education Department grants a large measure of autonomy, the character of which is indicated in their Circular of August, 1901: 'My Lords are of opinion that any scheme of technical education would be incomplete which did not provide instruction of the very highest kind in applied Science and Art to selected students who will devote their whole time to study. They think, therefore, that a further differentiation of institutions is necessary, and that instead of all alike being subjected to the same set of regulations, as has been done hitherto, a few which have had an outstanding record of success in the past, which are well staffed and well equipped for a considerable variety of work, and which are situated at the natural centres of population for large areas, may be allowed to proceed upon lines of their own, in the hope that they may develop into institutions worthy to rank, *not in number of students, but in quality and* advancement of work, with the best of their kind in any other country. It is from such institutions, and the opportunities of research and discovery which they will naturally afford, that decisive advantage to the industries of the country, in so far as that is dependent on educational arrangements, is to be looked for.' In pursuance of this policy the Department has established three agricultural colleges in Scotland, namely at Aberdeen, Edinburgh, and Glasgow. With the last-named centre is incorporated the dairy school and experimental station near Kilmarnock. That these three institutions are applying themselves with much energy to the accomplishment of the objects adumbrated in the above abstract from the Department's Circular is evident from the following tabular statement for 1905–6:—

Institution.	Number of Students.				Grant from Department.
	Day.		Evening.	Extension.	
	General.	Short Course.			
Aberdeen and North of Scotland College of Agriculture...	43	125	22	35,371	£2251 14 5
Edinburgh and East of Scotland College of Agriculture...	68	45	185	6,704	£2030 14 2
West of Scotland College of Agriculture	90	228	131	10,713	£3031 1 2

Students from these colleges are eligible for the degree of B.Sc. (Agric.) in the university with which they are respectively associated.

Brief mention may now be made of agricultural education in British Colonies and other possessions, and in foreign countries. Ireland is dealt with in separate article below.

Canada since 1874 has possessed an agricultural college of the first rank situated at Guelph, to which a farm of 550 ac. is attached. The course extends to three years, and is partly practical. It attracts large numbers of students, some coming from the United States and other countries.

In 1907 Sir William Macdonald presented a very large sum of money for the purpose of establishing a college of agriculture associated with the M'Gill University in Montreal. Magnificent buildings have been, or are being, erected for the accommodation both of men and women, with extensive grounds for practice and experiment. Agricultural teaching enters largely into the curricula of the rural schools of Canada, and the wants of practical farmers are met by farmers' institutes and similar organizations, which are visited and addressed by experts. Here and in the United States specially equipped railway carriages are not infrequently sent from district to district, in which lectures are delivered and from which bulletins, &c., are distributed. In places where public halls are not available they have proved most useful.

The government experimental farms of Canada are regarded as one of the most important of the educational agencies. Of these there are five—one central and four branch—all being created under an Act in 1886. Primarily they serve as stations of demonstration and research, but much of their value lies in the fact that they are bureaus of information available to all agricultural applicants. Nearly a hundred thousand letters are sent out annually, besides some 300,000 bulletins.

In Australia each of the States has an agricultural college of first-class rank, generally associated with, though not close to, a university, which grants a degree in rural economy. Winter schools, as well as post-graduate courses, are frequently held in these colleges. Then again, there are many secondary schools of an agricultural character, where the pupils give half their time to theory and half to practice. All the States possess travelling experts in special subjects — dairying, fruit growing, viticulture, &c.—part of whose duty it is to instruct the teachers in primary schools how they may best utilize for educational purposes the ground reserved to many rural schools under special Acts.

The Cape of Good Hope, the Transvaal, the Orange River Colony, and Natal are all engaged in perfecting the educational machinery requisite for the training of young farmers. India, under Lord Curzon's administration, has set herself to provide an agricultural department for education and research in every province; and, with Mr. Phipps's generous donation as a foundation, has equipped a magnificent station for agricultural research at Pusa.

Beyond the British Empire the value of education applied to rural affairs has long been recognized by most countries. In the United States of America the organization for teaching and research is very extensive. By an Act passed in 1862, large grants of public lands were made to each State and Territory for the purpose of providing at least one 'College of Agriculture and the Mechanic Arts'. The sales of these lands already aggregate $12,000,000, while about half as much again is still held in reserve. An Act passed in 1890 allotted a further grant of $1,200,000 annually, and this was further supplemented recently by the Nelson Act, which places an additional $5000 at the disposal of each college. In the department of research the Federal Government is equally lavish. Originally each State had $15,000 per annum placed at its disposal for the creation of an experimental station, but this has been largely added to by the Adams Act and by private endowment. The annual vote for the service of the central office of experimental stations in Washington exceeds $1,000,000, besides $25,000 voted for the distribution of farmers' bulletins. The lower grades of agricultural instruction, and the special types (horticulture, dairying, forestry, veterinary science, &c.), are also provided for in the most ample fashion. An important feature of activity in research and education in agriculture in this country takes the form of annual conventions, which serve as the medium for the exchange of ideas between workers engaged in similar pursuits.

Egypt has for years possessed a well-staffed agricultural college at Ghizeh, to which the fellah resorts in ever-increasing numbers.

In Europe we find Denmark, Holland, Belgium, Austria, Hungary, Italy, Switzerland, Norway, Sweden, France, and Germany with elaborate systems of agricultural education and research, all of which are modelled on similar lines. We need therefore only sketch the organization in the two most important countries—France and Germany.

In France, rural object lessons are a feature of all elementary country schools. In the higher elementary schools (*Écoles primaires supérieures*) the principles of agriculture are definitely taught. Farm apprenticeship schools (*Fermes-écoles*) served a useful purpose at one time, but are now largely discontinued, their place being taken by practical farm schools (*Écoles pratiques d'Agriculture*). These receive pupils, usually thirteen to fifteen years of age, from the elementary schools, and provide for them a three-years course, about half of which is open-air and half classroom instruction. General education in these schools goes hand in hand with technical. Not infrequently special dairy and other schools are associated with these institutions. Higher up the scale we find the *Écoles professionelles*, where experts in horticulture, cider making, vine growing, &c., are trained. Corresponding to our higher agricultural colleges, France provides three national colleges of agriculture, offering courses of two and a half years, while she also has schools of forestry, veterinary science, and sheep breeding. Crowning all is the *Institut National Agronomique* in Paris, whose functions are partly general, partly research, and partly—and perhaps chiefly—for the training of agricultural professors. Many well-equipped agronomic stations for experiment and demonstration are distributed throughout the country.

In Germany we find gardens playing an important didactic part in the primary schools. From these the sons of well-to-do farmers repair to the agricultural schools (*Landwirtschaftliche Schulen*), which differ from the *Gymnasia* and *Realschulen* in this, that there agricultural science takes the place of classics and modern languages respectively. The usual duration of

the course is three years. For boys who have to rest satisfied with a cheaper form of education, the farm schools (*Ackerbauschulen*) have been provided. To these a farm is attached, on which a part of each day is spent in manual exercises. Winter and evening schools (*Fortbildungsschulen*) are available in most districts for young men who can only get away from the practical work of the farm in the winter or in the evenings. Special schools in dairying, fruit growing, &c., of all degrees of elaboration are met with where there is an obvious demand for them. A great feature in German agricultural education is the peripatetic expert or teacher (*Wanderlehrer*), who is generally employed by a provincial or other local society, and whose business it is to hold local meetings in order that the latest advances in agricultural science may be brought before practical farmers.

Lastly, we have the agricultural colleges and agricultural departments (generally called Institutes) of universities, where the highest forms of study and research may be prosecuted, and where a degree in agriculture may be obtained. Most of the universities possess such Institutes, the best-known being Berlin, Halle, Leipzig, Göttingen, Rostock, Bonn, Kiel, Königsberg; while of colleges of equal rank, but not associated with a university, mention may be made of Weihenstephan in Bavaria, and Hohenheim in Würtemberg.

(For an exhaustive examination of agricultural education in England and Wales the report and minutes of evidence of the Departmental Committee of 1908 may be consulted.)

[W. SO.]

Education, Agricultural, in Ireland. —The first movement in the direction of agricultural education in Ireland was made in 1826, when a committee of Ulster gentlemen, having collected and subscribed a large sum of money, established a residential agricultural school at Templemoyle, in county Londonderry. The education given at this school was essentially practical, its exclusive function being to train skilled farmers. The fee charged for board and instruction was from £10 to £12 per annum, and there were annually in residence from fifty to seventy pupils, who were drawn not only from Ireland, but from different parts of England and Scotland. For nearly a quarter of a century the school was self-supporting, but mainly as a result of the famine of 1847 the committee of management began to encounter financial difficulties, and in order to relieve themselves of further responsibilities they, in 1850, handed over the institution to the Board of National Education.

Twelve years subsequent to the establishment of the Templemoyle school (viz. in 1838) came the first attempt of the National Board to grapple with the subject of agricultural education. They began by giving a daily lecture on agricultural science to the students attending the Marlborough Street (Dublin) Normal School for the Training of Elementary Teachers. At the same time the Board realized that such instruction would be useless unless the students were given an opportunity of seeing its practical application on the farm. Accordingly in the same year they acquired the farm at Glasnevin, to which the teachers in training might have easy access, and at which they might see the practical carrying out of the systems of agriculture and horticulture recommended in the classroom. Thus the primary purpose of the Glasnevin farm was different from that of Templemoyle in that it was intended merely to qualify elementary schoolmasters to give their pupils lessons in the theory of agriculture and, where possible, to illustrate these lessons by reference to the operations on the gardens and small farms attached to the National Schools. While this was so, it was not, however, the exclusive use to which the farm was put, as young men who intended to become farmers or land stewards were also received as pupils. This move on the part of the National Board was enthusiastically welcomed by all classes of the community, and the Devon Commission in 1843 recommended the establishment of agricultural schools throughout the country. This recommendation, however, did not take definite form till 1849. In the year previous to that, the Lord-Lieutenant (Lord Clarendon) appointed a number of instructors, whose duty it was to visit farmers, especially in districts which had been ravaged by the famine, and advise them as to improvements in their methods of farming. The work of these men was received with such acclamation that the National Board, feeling that there was a genuine desire for agricultural education being awakened, decided to give practical effect to the recommendation of the Devon Commission. Accordingly they proceeded to lease a number of farms in different parts of the country, at each of which accommodation was provided for a number of resident agricultural pupils and arrangements made for their instruction. In 1849 four of these farms were in working order, and in 1856 twenty were in full working order. In addition to these public institutions, numerous farm schools were opened under private influence which received financial assistance from the National Board. In 1850 the Board decided to encourage agricultural education in the workhouse schools. Where a farm was attached to a workhouse, a gratuity was offered to the teacher for successful management of the farm and for the giving of efficient instruction to the pupils.

Before long, however, an agitation, which originated with the Liverpool Financial Reform Association, against the whole system of agricultural education in Ireland began to gain ground in England. The right of the State to train farmers and stewards at the public cost was vehemently disputed. Successive Governments were hard pressed in their efforts to defend the system, and ultimately in 1862 the grants in aid of workhouse schools had to be abandoned. In 1870 the Royal Commission on primary education recommended that the number of provincial agricultural schools should be reduced. By the year 1872 the enthusiasm of the Irish people themselves had reached a very low mark, and the Lord-Lieutenant (Lord Spencer) endeavoured to revive that enthusiasm by instituting, in two districts in each of the four provinces, a system

of awarding prizes for the best-managed small holdings under £8 valuation in each district. This system was continued for five years, and was undoubtedly successful in encouraging the small farmers to make the most of their holdings. But in the meantime a Departmental Committee was appointed by the Treasury in 1873 to investigate the affairs of certain Irish departments, among them the National Board of Education. They found that, exclusive of Glasnevin, there were in the other twenty agricultural schools only thirty-three resident pupils. The natural consequence was that the Committee recommended that the Board should get rid of the provincial schools as quickly as possible. This course was accordingly adopted, with the result that by the year 1880 all the farms were disposed of except that at the Munster Institute, Cork, and that at the Albert Institution, Glasnevin. The chief reason for the retention of the latter was to afford facilities for the agricultural training of the pupils attending the Marlborough Street Normal School. The Munster Institute was retained through the co-operation of a committee drawn from the city and county of Cork who were anxious to make it a centre not only for the practical instruction of agricultural students, but also, and chiefly, for the training of dairymaids.

A few years previous to this, agriculture had been a compulsory subject in primary schools, and a results fee was paid for proficiency in the subject. In order to qualify schoolmasters, who had not had the opportunities afforded to the Marlborough Street students of acquiring a knowledge of agriculture at Glasnevin, to earn this grant, classes of about fifty were brought to Glasnevin each year, where they received a special course of training of six weeks' duration.

This work continued until the Agriculture and Technical Instruction Act of 1899 brought into existence the Department of Agriculture and Technical Instruction, which body, being the authority charged with the duty of providing agricultural education, took over from the National Commissioners the two institutions remaining in their hands, viz. the Albert Agricultural College, Glasnevin, and the Munster Institute, Cork.

In the carrying out of the programme of agricultural education which the newly formed Department had mapped out, the first difficulty they had to face was the absence of qualified teachers. Accordingly a Faculty of Agriculture was at once added to the Royal College of Science, Dublin. There scholarships are provided for men who are likely to become teachers, and who have already acquired a sound knowledge of practical farming. A three years' course of training in science and its application to agriculture is provided in order to fit these men to become agricultural instructors. Thereafter they receive appointments as instructors under a County Committee of Agriculture, or at one or other of the agricultural stations and institutions directly under the control of the Department.

The course at the Royal College of Science, however, being of a university standard, only attracts those whose ultimate aim is to become teachers. It is not attended by men who desire a more limited training and then return to their farms. Such a course is provided at the Albert College, Glasnevin, where practical and theoretical instruction are both given. The best of the pupils at Glasnevin usually obtain admission to the Royal College of Science, to undergo there the higher course of training. There is also a horticultural school attached to the Glasnevin College, where men are trained to fill the posts of horticultural instructors under the various county committees.

Three other institutions for the training of men—agricultural stations as they are called—have been established by the Department. At these the training is of a still more practical nature. The course extends for one year, and the great majority of the pupils return to their farms, although a very limited number find their way to Glasnevin, and thence to the College of Science. In addition to the training of young farmers, these stations perform other useful functions, such as the carrying out of experiments, and the breeding and distribution of pure-bred sires for use under the Department's schemes of live-stock improvement.

Another form of instruction is that provided at the winter schools of agriculture. These schools, although directed and supervised by the Department, are under the control of the County Agricultural Committees, and the expenses connected therewith, with the exception of the salary of the teacher, which is paid by the Department, are a charge upon the Committees' funds, these being derived partly from the county rates and partly from Departmental grants. The schools are open at local country centres for about twenty weeks from October to March, and are attended by young men who are actually engaged at farm work. Each school is open for two or three days per week, and thus the same teacher is able to attend at three or two different schools as the case may be, while at the same time continued absence from home on the part of the students is avoided. Expenses of equipment are limited to a very small sum, and instruction is given in such matters as have a direct bearing on farm practice. It may be noted that while in 1902 there was only one such school in Ireland, in 1908 there have been established about fifty-five schools in twenty-one counties.

Lastly we come to the scheme of Itinerant Instruction in Agriculture. This is the pioneer work of the whole system, without which the other forms of education already referred to would not be possible. The instructors deliver lectures, carry out experiments, advise farmers by letter or by personal visits, assist in the checking of fraud in the sale of seeds, manures, and feedingstuffs, adjudicate in the Cottage and Farm Prize Competitions, and in many cases discharge duties in connection with the live-stock improvement schemes. In 1900 one county had its instructor—in 1908 every county has one, and several have two instructors.

It will thus be seen that the Department has developed a graduated system of agricultural

education which will enable an intelligent young farmer, who has been inspired by the teaching of the itinerant instructor, to obtain a thoroughly sound agricultural education, first at the local winter school, then at the agricultural station, then at the Albert College, and finally at the Royal College of Science.

It only remains to be said that the training of women teachers and workers, which in many ways is as important as that of men, has not been overlooked by the Department. In fact, with the exception of the university course, similar provision is made for women as for men. There are two training schools for teachers of dairying, poultry keeping, and farm housekeeping, and there are also a number of subsidiary schools from which the most capable pupils are sent to the training schools, while itinerant instructors in dairying and poultry keeping are employed in almost every county in Ireland.

[J. Wo.]

[*Note.*—The historical portion of this article is taken from a letter written in January, 1883, by the late Sir Patrick Keenan, K.C.M.G., C.B., Resident Commissioner of National Education, to His Excellency the Earl Spencer, K.G., then Lord-Lieutenant of Ireland. This letter is reproduced in IRELAND, INDUSTRIAL AND AGRICULTURAL.]

Education in Rural Schools.—The means adopted to educate or draw out the mental powers of a child were at one time practically the same in all schools. The subjects were reading, writing, and arithmetic in the lower classes, and languages and mathematics in the higher classes. In the lower classes the subjects are the same as of old, but they are taught in a more intelligent way. Teachers have a better knowledge of the child mind than formerly, and a clearer conception of the processes of mental development. The newer and more rational methods of education were first introduced into the larger city and town schools, but they are now generally followed even in the most rural schools.

The school subjects of the higher classes have, however, undergone a radical change. It is now recognized that languages and mathematics are not the only suitable means of education, and that these subjects are for the average, and especially for the duller pupils, probably the least effective. For the few boys of intellectual cast of mind, languages and mathematics will always hold their place, but abstract ideas and theoretical problems do not appeal with any force to the general mind. In order to meet the case of the average and the dull pupil the Real School has been evolved, and pupils deal with realities and occurrences in preference to abstractions and illustrations.

A certain cast of mind can be educated best through the hand. Manual training in paper work, in woodwork, or in gardening has been introduced, and pupils are required to perform certain operations, the performance of which stimulates the motor centres of the brain. It is found that pupils, after undergoing such a course of education, approach abstract and intellectual processes with new interest and vigour.

But languages and mathematics, even when suitable subjects of education, do not give much information which is of practical use in the subsequent career of pupils who are to devote their lives to rural pursuits; whereas nature study, woodwork, and gardening, besides being equally good means, in competent hands, of mental discipline, leave with the pupil certain information which is of practical use in after-life.

Rural work calls for more intelligence and observation power than most occupations. Few rural operations are of a purely mechanical nature, and, alike from their variety and nature, they make a constant call for powers of observation and inference.

The older race of farmers, shepherds, and gamekeepers were keen observers, and the children learned from the fathers; but in modern times the pupils are for the greater portion of their early years under the care of the teacher, and it is the more necessary that the school curricula should supply what would otherwise have been gained in the course of nature. Besides, it is eminently desirable, in view of the depopulation of the rural districts, and the consequent dearth of agricultural labour and the overcrowding in towns, with the resulting loss of virility in the race, that pupils should receive a bias towards rural life and work. The older forms of education diverted the best brains of the country district into the professions, and though this may be always more or less the case, something may be done to give the rank and file a more pleasurable anticipation in beginning country work.

Practical science work is an important subject of education in most large schools, and well-equipped chemical and physical laboratories are to be found in these schools. In the small rural school such equipment is impossible, alike from the cost of installation and the dearth of pupils of suitable age. But the rural school has its compensation. It is close to nature's laboratory, where the myriad processes of animal and vegetable life are in evidence. Nature study takes the place of laboratory work, and does so with one manifest advantage: the problems of nature are so varied as to suit the child mind at all stages of growth. The youngest child may watch the bright-coloured yellow, blue, or red spotted butterflies as they flit from flower to flower; the older pupils may trace the evolution from the egg to the caterpillar, from the chrysalis to the butterfly; while the senior pupils may compare the local colour of the butterfly with its surroundings, and the provision made by nature for its safety from its enemies.

The life-history of the frog may be daily watched even in the classroom, and the growth of a plant, such as the bean, may be a source of interest and education, and of subsequent practical use to the pupils.

One other general observation falls to be made. The rural population must depend largely on itself for the means of recreation and enjoyment, and during the school career such a love for nature study, for gardening, or for some such pursuit should be developed as will afford a means of profitable and pleasant occupation during the hours of adult leisure.

A word of warning, however, must be given.

The value of the method of education outlined will depend on the manner in which the work is carried on. The teacher must not tell the pupil things. In the past, too much information has been asked of children, and the natural tendency of teachers has been to fill the memory with isolated facts. The memory may be cultivated at the expense of higher qualities of mind, observation and deduction. The pupils must be allowed to discover things for themselves. The teacher may guide them, may lead them near to the point to be discovered, may by judicious questioning direct the observation power, but the actual observation must be made by the individual pupil. Progress will be slow, painfully slow at first; but the very fact that progress is so slow only confirms what has been said as to the eminent suitability of this method of education for a particular type of mind. All the subjects should be correlated. Leaves and insects collected by the children should be the objects of the drawing lesson; the laying out of the school garden a lesson in practical mensuration; the cost of seeds or the sale of produce a lesson in arithmetic; and the profit and loss, one in book-keeping. Composition and spelling, if correlated to the nature study in garden work, become natural modes of expression, and pupils unconsciously learn to compose and spell. Composition is sometimes taught by reading a story to the pupils and asking them to reproduce the meaning, or a piece of poetry is read and a prose paraphrase is requested. Now there are two mental processes here going on, and one is apt to conflict with the other. The pupil has the difficulty of clearly understanding the story or the poem, and secondly of expressing what he thinks. The critic of such work cannot know with certainty whether the looseness of expression arises from want of clearness of conception, or from lack of the ability to express. In describing a thing or a process which the pupil knows, he is doing one thing only, and any inaccuracy can be at once fixed on by the teacher, and the faulty expression is seen to be so by the pupil.

Moreover, the call for accurate verbal description reacts on the observation powers of the pupil and forces him to look once again more carefully, and warns him in future to be more exact in his study. The enthusiastic supporters of such education even go further, and say that the very fact that the pupil must habitually observe carefully and state exactly what he sees, fosters the habit of truthfulness.

Thus far we have dealt mainly with subjects specially suitable to boys. Girls, however, may join in such subjects, with the exception of woodwork, with profit. There are, however, a number of subjects specially applicable to girls, namely cookery, laundry work, and household economy generally. The equipment necessary for practical instruction in these subjects is not specially costly, and the difficulty of a suitable teacher may be overcome by a lady member of the staff qualifying during the summer recess, or by the school authorities securing the services of a peripatetic teacher.

Having now discussed the general aim of the subjects of instruction specially suitable for rural schools, we append examples of the course of study recommended by the Board of Education in England and by the Scotch Education Department.

SUGGESTIONS FOR NATURE STUDY.—(*a*) Encourage the little children to bring a flower, leaf, &c., to school, a new one each day, and use them as far as possible for decorative purposes, being satisfied at first by merely stimulating wonder, interest, and delight in natural objects. Throughout school life it is desirable that the children should be encouraged to bring things to school that appear to them to be interesting; the teacher may thus learn as much as the children, and the school cabinet may become a really valuable museum of local natural history.

(*b*) In the autumn or the summer get the little children to bring the leaf of a tree to school, a different one for each lesson; let them get a record of their shapes on paper, afterwards filling in the midribs and veins, and colouring with a brush. Get the children to try to describe the size, shape, margin, and colour in their own words, thus: egg-shaped, finger-shaped, toothed, and so on. Each child will in time get quite a collection of drawings, and will get to observe differences of form. Later on, in the fourth or fifth class, the pupils should unite in making a collection of specimens of the bark, wood, twigs, buds, leaf, flower, and fruit, with a drawing or photograph, of each kind of tree growing in the neighbourhood.

(*c*) Get the children to grow seeds between the side of a tumbler or lamp-glass and a piece of blotting paper fitted within it. Let each child, if possible, have a separate experiment, and have the responsibility of keeping the paper sufficiently moist. Let it draw the bursting seed and growing seedling day by day; never mind at first how badly the drawing is done, it is trying to do it that matters. Above all, do not show the child how to do it, for we must avoid the possibility of the child learning to draw what it thinks it ought to see. Next year, using the same device, let them study how seeds germinate, keeping one tumbler in the dark, another in the light, one tumbler in a cold, another in a warm place, another half-filled with water to exclude air, another without water enough to keep it moist, and get the children to describe in their own words what they learn from their experiments. Similar experiments may be made upon how plants grow from seedlings.

(*d*) Study the growth of plants from seeds, bulbs, and corms in soil. This can be done in such a way that the plants become an ornament, not a disfigurement to the schoolroom. Organize an exhibition of plants grown by the children in their own homes, either confining the exhibition to the one school, or extending it to a group of schools.

(*e*) Study animal life as far as this can be done in the schoolroom by means of an aquarium for water beetles, newts, frogs, &c., and by means of boxes with glass fronts and perforated zinc backs for butterflies and moths. Get the children to make drawings, and to describe in their

own words the changes they observe, carefully revising the written work with a view to securing definiteness and accuracy of observation. In the neighbourhood of the sea, a salt-water aquarium should also be kept, and the living objects of the sea and seashore compared with those of land and fresh water. Having secured a coloured picture of a bird common in the locality, set the children the exercise of observing its habits, especially its food, during their time out of school, and when sufficient time has elapsed, get them to write out an account. All the commoner birds should be thus studied.

(*f*) Let all the children of one class unite in making a collection of wild flowers, pressing, mounting, and naming them with the common names, sorting into families those more easy to recognize, *e.g.* the composite, leguminous, cruciferous, and gramineous plants, and also classifying them according to their habitat, *e.g.* hedgerow, marsh, clay-land, light-land, and moorland plants.

(*g*) Study the physiographical features of a neighbourhood: the work of the streams in carving out a channel, and in depositing gravel, sand, and mud; the geological outcrops that form the subsoils, with the soils lying upon these; the perviousness of the various soils to water, and their power of raising water by capillarity; correlating these with a rough determination of the proportion of stones, mud, sand, as ascertained by stirring the soils with water in a narrow glass and allowing to settle; the difference in the hardness of the water as it falls in rain and as it issues from springs and land drains, indicating the dissolving out of lime from the soil; the trees, crops, and wild plants growing on each type of soil and at different elevations. This physiographical nature study involves some out-of-door work of the pupils with the teacher. Its importance, however, is very great.

(*h*) Let some of the boys take turns, two at a time, in reading and recording the barometer, and wet and dry bulb thermometers when these can be procured, plotting the variations on squared paper and issuing weather forecasts.

For Boys in the Upper Classes only.—(*i*) Study the grasses, collecting bunches of the flowering heads, and also mounting specimens to show roots. Name them with the common names, and sort them into useful, useless, and injurious grasses; into annual grasses that propagate themselves by seed, and perennial grasses, some of which propagate themselves also by underground stems; into grasses characteristic of wet land and dry land, pasture, meadow, and moorland. Clumps of the grasses might be grown in the school garden.

(*j*) Study the weeds common in arable farm or garden land in the neighbourhood, especially their time of seeding and root systems, with a view to understanding the best means of eradicating them.

(*k*) Study the insects of economic importance, including (1) bees, for which an apiary must be started; (2) injurious insects, such as Winter and Codlin Moth, Ox Warble Fly, Gadfly, Wireworm, Crane Fly, Turnip Flea Beetle, Aphis (various species), and Black Currant Mite. The work should include not only observations of their life-history as far as this is possible, but also the collecting of specimens of egg, larva, pupa, and perfect insect, with examples of damage done, and information on the natural enemies and preventive measures. This information the boys should be encouraged to get from external sources, and schools undertaking this study should apply for leaflets of the Board of Agriculture, which will be invaluable for reference.

(*l*) Collect farm and garden seeds with a view to learning to recognize them and their impurities, and to judge good seed; test them for germinating capacity by placing them on moistened blotting paper in an incubator rigged up by the boys. Separate clumps of each kind of seed might be sown in the school garden.

(*m*) Make a scrapbook of farm stock with a view to learn to recognize the principal breeds of horses, sheep, cattle, pigs, and poultry, the

Month, ... NATURE CALENDAR Year ......

Date.	Object.	Observation.	Observer.
	(Name of bird.)	Seen (if rare) arriving, building, sitting, singing, young birds hatched, young birds flying, feeding on ——, migrating.	
	(Name of fish, reptile, or amphibian.)	Spawning or laying eggs, hatching, changing form.	
	(Name of wild animal.)	Seen (if rare) emerging from hibernation, feeding on ——.	
	(Name of beetle, moth, butterfly, caterpillar, &c.)	First seen, where seen, feeding on ——.	
	(Name of wild flower.)	First seen in flower, where seen.	
	(Name of tree.)	In leaf, in flower.	
	(Garden crop.)	Sown, pricked out, planted out, earthed up, ripe for gathering, &c.	
	(Farm operation.)	Leas ploughed, wheat sown, hedges layered, lambing begun, spring corn sown, seeds sown with corn, cows turned out to pasture, land prepared for roots, sheep washed, roots hoed and topdressed, sheep sheared, turnips singled, haymaking begun, sheep dipped, harvest begun, crimson clover sown, &c.	

scraps being obtained by the boys from agricultural and local papers. Similar work might be done in garden crops.

(*n*) Cultivate school garden plots, regarding the work as the study of the growth of plants in relation to the soil.

For Girls in the Upper Classes only.—(*o*) Where poultry are kept, allow a few girls to share in the management of the yard, studying the good qualities of the various breeds, keeping a record of the eggs, treating the ailments, and keeping notebooks and accounts.

(*p*) Make a study of milk, and measure the cream that rises to the top of various samples. Rinse out one test tube with pond water, another with spring water, and observe how long milk with which they are afterwards filled takes to curdle, and whether in the first case a taint is produced. Keep one test tube of milk in a warm place and one in a cold, and observe times of curdling. Repeat the first experiment, but first boil the pond water. A number of similar experiments can be devised.

Month, ... METEOROLOGICAL CALENDAR Year ......

Day of Month.	Outside Temperature at Noon.	Reading of Barometer.	Sun's Altitude at Noon.	Inches of Rain.	Direction of Wind.	General Description of Weather.
1						
2						
3						
4						
5						
&c.						

SCHOOL GARDENING. See GARDENS, SCHOOL.

The following syllabus of instruction is recommended by the Scotch Education Department for pupils between the ages of twelve and fourteen who are attending rural schools.

COURSE FOR RURAL SCHOOL

(1) Nature Study.—Continued so as to secure on the part of the pupils familiarity with (*a*) the rocks, soils, and plants of the district; (*b*) the life-histories of weeds and insect pests, with the remedies against them; (*c*) wind and insect pollination of plants; (*d*) relations of air, water, and soil to vegetable and animal life.

Note.—Instruction in the above subjects must throughout be of a practical character. To this end, school gardens should be formed and made use of; observations on bees and beekeeping should be made where possible; and advantage should be taken of any agricultural experiment stations in the neighbourhood. When the instruction is of a sufficiently practical character, given through the medium of a school garden, special grants will be allowed.

(2) Geometry and Mensuration.—(*a*) Construction and measurement of figures drawn to scale by the use of compasses, protractors, set squares, &c.; (*b*) construction and use of graphs; (*c*) for advanced pupils, mensuration of regular solids.

Note.—The teaching throughout must deal with concrete problems; and in the use of mathematical instruments correct methods and exactness of measurement must be looked upon as of prime importance.

(3) Study of Newspaper Market Reports.—With exercises and calculations based upon these.

(4) The Keeping of Accounts.

(5) Optional.—Woodwork (or ironwork).

[J. Cu.]

Eelworm. See ANGUILLULIDÆ, TYLENCHUS, and HETERODERA.

Egg, Structure of.—The shape of a hen's egg is familiar to all; it is longer than it is broad, and has one pointed and one flattish end. The weight, which averages about 2 oz., varies according to the breed, some eggs weighing 2¼ oz. or more, while others do not turn the scales at 1¾ oz. The outer covering of the egg is sometimes white, sometimes dark-brown, and sometimes fawn, the colour depending in a large measure on the breed or variety of the hen. This covering or shell is composed of carbonate of lime, phosphate of lime, and animal gluten. It is perforated by a multitude of microscopic holes through which fresh air enters to the embryo during incubation and the poisonous products of respiration are expelled. From the moment the egg is laid, there is a constant evaporation of the contents going on through these holes. The rapidity of this evaporation depends upon the conditions and the temperature under which the egg is kept, as it is considerably quicker during the summer than during the winter, and if subjected to a high temperature it is very rapid indeed. Adhering to the shell are two membranes, termed the inner and the outer membranes, which are slightly connected to each other, excepting at the broad end of the egg, where they separate to form the *air space*. As evaporation takes place the air space increases in size, and by this means the age of an egg can be determined to a nicety. In an egg which is new laid the air space is quite small, whereas in one that is say three weeks old it probably occupies one-seventh of the entire space.

The white of an egg is in three distinct layers, the outer, the middle, and the inner; these can be seen plainly in a hard-boiled egg, as the layers frequently separate when the egg is cut in two. The white consists mainly of albumen in a transparent and liquid form, free from smell or taste, and is composed of carbon, oxygen, hydrogen, nitrogen, phosphorus, and sulphur. The yolk is enclosed by a very thin sac, termed the vitelline membrane, and being less dense than the white, whichever way the egg is turned it is always on the upper side. This is composed of organic salts, vitelline, albuminous matter, a fatty phosphoric substance, and colouring matter. In shape it resembles a thickened horseshoe, the inner portion, the utricle, being composed of a

considerably lighter material. The chief purpose of the yolk is to supply the embryo with nourishment during development and during the first three or four days after hatching; immediately before the chicken makes its exit the remaining portion is absorbed into the lower part of the digestive tract, and contains sufficient nutriment for the time mentioned.

Fastened to each end of the vitelline membrane are two cords of thickened albumen, twisted in form, called the chalazæ; these terminate in the middle layer of white, and their purpose is to keep the yolk in position; were it not for these, it would float freely in the white. These are the two parts always removed in beating an egg; it is often thought that they have something to do with the germ of life, but this is not the case, their sole use being to keep the yolk in position. The germ contained in a fertile egg is quite invisible to the naked eye, but it is situated within the vitelline membrane at the mouth of the utricle. [W. Br.]

Eggs, Packing of. — The methods of packing vary very greatly, each country having to a certain extent its own system. At the present time, however, all foreign and the best Irish eggs are packed in long wooden cases holding twelve 'long hundreds' (1440), and they have a double partition in the centre, so that by sawing in two, two half cases are obtained without unpacking. For long distances these cases are undoubtedly the best, and the boxes being cheap they are non-returnable, a fact which saves a large amount of labour and curtails the expense to the producer. The material employed in packing is usually clean, straight straw, but some Continental traders are using wood wool; this is an excellent substitute, though not so good. Owing to the fact that the eggs for foreign countries are all graded to size, they travel quite safely.

In this country, eggs have only to travel a comparatively short distance, therefore other cases are generally used. In some instances, baskets holding from five to ten long hundreds are employed, but there are now several boxes on the market which are equally good.

The three essential features of a good eggbox are: (1) easy to pack and unpack, (2) safe in transit, and (3) easy to clean if an egg should get broken. The best boxes are fitted with cardboard sections, with a layer of wood wool between the sections. Renewals are cheap, and if the boxes are made of laths of wood about 1¼ in. apart, there is a great saving in carriage. Other boxes are fitted with felt-covered trays, but they have this disadvantage—they are difficult to clean if an egg happens to get broken. One most important matter is that the packing material shall be clean and sweet. Eggs are very susceptible to external influences, and if the straw or wood wool is dirty they will be affected by it, and may become tainted though quite fresh. [W. Br.]

Eggs, Preservation of. — During the last two or three decades, eggs have ceased to be a luxury and have become a necessity, and the demand in this country is enormous all the year round. Unfortunately, the supply is limited during the colder months of the year, and therefore there is a considerable difference in price between the winter and spring trades, and this fact has led many connected with the marketing of eggs to experiment in preserving this necessary article of food.

Although it is possible to preserve eggs successfully for a certain period of time, no method has yet been discovered which will keep them in exactly the same state as when laid. No preserved or pickled egg has ever the 'milky' white which is such a distinctive feature of the new-laid, and, moreover, changes take place within the shell whenever eggs are kept, over which all preservatives have only a limited control. A very large proportion of the foreign or box eggs which are received in Britain have been held over from the plenteous to the scarce season of the year, and all users agree that they are nothing like the fresh article.

To secure effective preservation there are two main factors—(1) to keep the yolk suspended in the centre of the albumen, and (2) to hinder evaporation of the liquid portion of the egg. The former is the more difficult to arrange, as it is frequently impossible to constantly alter the position of each egg. An interesting point arises as to whether an infertile egg will keep longer than one in which there is the germ of life. We know that the former cannot go rotten—only dry up—whereas one which contains life can decompose; therefore it is to be recommended that when eggs are to be put down, infertiles should be used for this purpose whenever possible.

No matter which method of preservation is adopted, there are two points which must not be forgotten. The first is that the eggs should be brought under the influence of the preservative as soon after they are laid as possible; and secondly, that they be kept at a fairly low temperature during the entire process. If these two suggestions are followed the results will be found to be better.

Various methods of preserving have been suggested, but only three of these are in common use. We refer to the (1) limewater process; (2) the use of waterglass (silicate of soda), and (3) cold storage. Of the other methods two may just be mentioned, namely, keeping in salt, and by rubbing the eggs with fat, butter, or glycerine. These latter do not, however, produce good results, besides being more expensive.

The limewater process is over a hundred years old, but even so it is still one of the best methods, being easy to carry out, and inexpensive. The eggs are placed in vats or tubs as soon after being laid as possible, and a preparation consisting of 20 gal. of water, 4 gal. of fine slaked lime, and 1 gal. of salt is poured over them. All the eggs must be well covered, some 2 or 3 inches of the liquid being above the top layer. It is sometimes found necessary to add a small additional quantity of lime during the process, and this is done by tying a cloth containing a little lime loosely over the top of the vat, so that it just touches the water. A rougher method is to throw in a handful of lime occasionally; but this is somewhat risky, for the

secret of the success of this method is only to use as much lime as can be taken up by the water.

During recent years the waterglass method has come into vogue. Waterglass is a soluble silicate of soda, and can be purchased from chemists in a concentrated form. A 10-per-cent solution is made in water, hot water being used as it takes less time to dissolve, and the eggs are covered with this liquid. It has been found in America that a 3-per-cent solution is as effective as 10 per cent. This system is perhaps the best when the number of eggs to be preserved is small, as the labour involved in making the preparation is not so great; though, on the other hand, it is rather more expensive than the limewater process.

The last method to be mentioned—although not practised extensively in this country at present—will undoubtedly come more into use in the future. Eggs can be kept in good condition for a short length of time under cold storage, but only in a few instances are these cold stores available. The effect of chilling is to hold all action in suspension, and therefore should prove successful, but the great difficulty is that the eggs will deteriorate as much in twenty-four hours after coming out of the cold chamber as will pickled eggs in a week or ten days after being taken out of the limewater. If, however, cold stores are in the neighbourhood they should be employed when the eggs have only to be held for two or three weeks in warm weather. The best temperature is 34° F., or 2 degrees above freezing-point. When the eggs are required for use, they should be gently raised in temperature by being kept for a few hours in a room about 38° F., gradually placing them in warmer air until the normal temperature has been reached.

If eggs have to be kept for two or three weeks only, they can be kept in quite good condition in a cool cellar or room if they are turned two or three times a week. In a low temperature the liquid portion of the egg does not evaporate so rapidly, and the effect of turning is to keep the yolk suspended in the centre of the white; therefore for a short period this method can be recommended. [W. BR.]

Eggs, Statistics of.—No definite estimate of the number of the eggs produced in the United Kingdom can be formed. The number of the hens forming the potential breeders is unknown. Even if the renewed attempt in the agricultural schedules for 1908 to collect returns of the numbers of poultry kept in Great Britain should prove more successful than the former effort at enumeration, the actual crop of eggs available for consumption in any year is not easy to compute. The importation of eggs from abroad, the sources of this supply, and its fluctuation in proportion to the total number of consumers in this country, may be nevertheless readily ascertained. In 'great hundreds' (120), which is the trade denomination employed by the Customs authorities in computing the annual imports of eggs, the year 1907 showed a slight falling off in the numbers received, or 18,568,000 great hundreds compared with 18,874,000 in the previous year, and 18,814,000 in 1905. In actual numbers of individual eggs, as these statistics are translated in the tables appearing both in the Statistical Abstracts of the Board of Trade and in the annual records of the Board of Agriculture, we received 2,228,148,000 eggs of all qualities and of varied origin in 1907; and this, although below the quota of the immediately preceding seasons, is very considerably more than in earlier years. These figures are too large to be easily grasped, and it is easier to form an impression of their magnitude by noting that this importation represents a value of over £7,000,000 sterling in recent years, compared with under £4,700,000 in the last five years of the 19th century. The value of the imports was little more than half that figure in 1876–80, and barely exceeded £1,000,000 in the five years 1866–70, the period with which our agricultural statistics themselves took their current shape. Put in another way, and in relation to the growth of our population in this country, it is calculated that in the five years last mentioned there were only imported 14 eggs per annum for each person here—a ratio which became 22 eggs to each person in 1876–80, 44 to each person in 1896–1900, and 53 per person in 1901–5. The maximum supply would appear to have been 56 eggs per person in both 1903 and 1904—a decline to 52 per person following in 1905 and 1906, and a further drop to 51 in 1907. This may perhaps be accepted as an indication of the result of the development of poultry keeping at home which is believed to have occurred.

At present and for some years Russia, with a highly organized collecting trade, has been very much the largest contributor to the foreign egg supply of the British people, more than 800,000,000 eggs coming into our ports annually for the last five years from this source. Although Riga is the principal port of export, the real source of supplies lies much farther inland in Tamboff, the Volga, and Kazan. Denmark follows Russia as a seller of eggs to this country, with an average of some 450,000,000, and Germany sends us a more fluctuating total, averaging 340,000,000. Belgium also figures in the return as another prominent transmitter of eggs to Great Britain; but her trade, as indeed that of Germany, is largely that of an intermediary, and the produce now reaching us from these countries may not unfairly be credited in great part to Austria-Hungary or other less populous States. The French export of eggs has declined of late, and among the other smaller sources of supply there are some unlikely countries mentioned, such as Egypt, Morocco, and even Turkey. The Canadian export, at one time noteworthy, has of late years considerably diminished, under 14,000,000 eggs coming from this colony in 1907, against 67,000,000 in 1903.

The average prices of British eggs were calculated by the Board of Agriculture at from 10*s.* 7*d.* to 11*s.* 7*d.* per 120 in 1906, and 10*s.* 10*d.* to 11*s.* 10*d.* in 1907, the Irish supply being put at 9*s.* 6*d.* to 10*s.* 6*d.* in 1906, and 9*s.* 9*d.* to 10*s.* 11*d.* in the later year. The Danish eggs were quoted at 9*s.* 9*d.* to 11*s.*, and 10*s.* to 11*s.* 2*d.*

in these years respectively. The range in different months is very wide—the British figures for best qualities in April running down to 7*s.* 6*d.*, and in December running up to 18*s.* It may be added that recent consular reports speak of Russian eggs as procurable in the interior at prices ranging from £2, 11*s.* to £5, 15*s.* for cases of 1440 eggs, to which the cost of railway transit largely adds—from Kazan to Riga costing £26 for a wagon load of 10 tons of eggs, the shipping freight thence to our ports running up to 23*s.* 6*d.* per ton. [P. G. C.]

Egypt, Agriculture of.—From time immemorial, Egypt has been mainly an agricultural country, parts of whose rich alluvial deposits have long been made to yield two and three crops a year by carefully regulated irrigation. Out of a total population of nearly 11 millions, over 2 million males are agriculturists belonging to the *fellahin* or peasant population of the Nile, and fully two-thirds of the entire population subsist from agriculture.

According to its physical features Egypt may be divided into (1) the agricultural portions, consisting mainly of the Nile valley and its delta, and the fertile oases in the western desert; and (2) the non-agricultural portions, including the desert plateaux and the mountainous eastern and north-eastern tracts. And of these the Nile valley and its delta are of by far the most importance as regards agriculture. The most fertile tract of all is the southern portion of the Nile delta, which extends north and south for 100 miles, and has a width of 155 miles along the Mediterranean coast, while its eastern and western limits are determined by the higher ground of the deserts, up to which the silt-laden Nile floods cannot reach. Near the coast line the delta is a barren area of sandhills and salty wastes except where reclaimed, but in ascending the Nile valley in a southward direction the quality of the alluvial deposits rapidly improves, so as to make them among the most fertile parts of Egypt. The delta soil is a fine dark-grey sand, with particles so fine as often to make it look like a stiff clay. This alluvium usually varies in thickness from 55 to 70 ft., although it often attains from six to eight times that depth in some parts; and the whole delta forms a wide alluvial plain only about 30 ft. above the sea-level at the highest point of its southern extremity.

From where it enters Egypt proper at 22° N. down to 25° N., the Nile valley rarely exceeds 2 miles in breadth, but from here onwards for over 500 miles to the sea the average width of cultivation is about 10 miles. This cultivable belt lies chiefly on the left bank of the river, its limitation being due to stony and sandy ground stretching up to the foot of the limestone hills in which this rift valley was originally formed.

In June the Nile water runs clear and without silt, but after beginning to rise in July the water in August is full of rich, dark, red-brown sediment of volcanic origin, brought down from the Abyssinian mountains by the Blue Nile and the Atbara, and estimated as being carried at the rate of 8 cu. yd. a second; but by September the amount of sediment decreases to about one-half, and soon afterwards the waters run clear again. It is this wet Nile-borne silt which has for ages been the great fertilizing agent throughout the valley and the delta of the Nile, although recent investigations seem to indicate that the Nile-borne silt does not vary much as to its mineral composition from the soil fertilized by the flood-water. But the fertility of the five great oases occupying depressions in the western desert (Siwah, Baharieh, Farafreh, Dakhleh, and Khargeh) is due to a plentiful supply of water, procurable from a bed of sandstone lying from 300 to 500 ft. below the surface, and which rises through natural fissures or artificial boreholes (artesian wells).

Egyptian agriculture is entirely dependent on a sufficient water-supply from the river or from artesian wells, because Egypt is practically an almost rainless country, with a high temperature by day and rapid radiation at night under a cloudless sky. At the coast there is slight rainfall during the winter months, which varies from about 1 in. at Suez to 8 in. at Alexandria, though even this last amount would be insufficient for agriculture; while the temperature varies from an annual minimum of 41° F. to an annual maximum of 118° F.

Although the total area of Egypt is about 400,000 sq. miles, the area of cultivable land either cultivated or under reclamation is only about $6\frac{1}{4}$ million acres, about 5 millions of which pay full taxes and $1\frac{1}{4}$ million proportional taxes according to degree of reclamation and the amount of water supplied for irrigation. But of these $6\frac{1}{4}$ million acres about 2 million acres are double cropped, and other parts even thrice cropped, so that altogether crops of one sort or another are harvested from about 8 million acres annually. In 1907 the total unwatered area under cultivation was only about 107,000 ac., while the 'half-sharáki' or insufficiently irrigated land was estimated at about 17,000 ac. Thirty years ago there were ten times as much unwatered or insufficiently watered land.

The agricultural year is divided into a 'summer season' from 1st April to 31st July, a 'flood season' from 1st August to 30th November, and a 'winter season' from 1st December to 31st March; and the approximate areas cultivated during these seasons are respectively about $2\frac{1}{4}$, $1\frac{1}{2}$, and $4\frac{1}{2}$ million acres (including areas twice or thrice cropped). The chief crops taken in summer are cotton, sugar cane, maize, and millet; in the flood season dates (especially in middle Egypt), maize, millet, and rice; and in winter wheat, beans, clover, barley, lentils, vetches, and vegetables. The land is everywhere subdivided into very small plots, each of which is often owned by the members of a family and still further parcelled out into individual shares; only about one-fifth of the total number of the registered proprietors hold 5 ac. or more.

The two main facts characterizing Egyptian agriculture are: (1) that the whole country (except the western oases) is watered by the Nile, and not by rainfall; and (2) that the river not only irrigates, but also fertilizes the sandy land with the reddish-brown mud washed down from the volcanic plateaux in Abyssinia. By

September the rising Nile has reached the top of its banks and begins to overflow except where restrained by artificial dykes, which have to be carefully watched by day and night, and banked up wherever necessary when the rise exceeds 27 ft. at Cairo (the normal rise being about 25 ft.)—such labour having been formerly exacted by *corvée* or forced service from the peasantry. In ancient times the annual rise of the Nile was almost entirely depended on for irrigation. The valley was intersected by dykes made at right angles to the current and reaching to the hills on both sides of the river, so as to form a series of 'basins' or catchment areas for the silt-bearing water, which were bounded by the river bank on one side and the higher desert land on the other. Each of these 'basins' or catchment areas was fed by a separate canal from the river, and had a separate escape lower down, by which the water could be run off again into the river after its silt was deposited during the six to seven weeks while the land remained flooded. On this muddy surface the seed was sown for crops to be harvested in March and April, after which the land lay fallow till the floods came again in September. For cultivation on a small scale water has long been raised from the river by the rude water-wheel or *sakieh*, and by the bucket hung from one end of a long pole pivoted on a support and weighted at the other end—the *shadoof*; but steam pumps are now common.

The old system of basin irrigation still obtains throughout nearly all Upper Egypt lying to the south of the apex of the delta. It costs little in labour, but only permits of one crop being taken in the year, as for about six months the sun-baked land remains arid, hard, and sterile. Hence in Upper Egypt, just as in the time of the Pharaohs, only a single-crop winter cultivation prevails, which is entirely dependent upon the land being annually inundated with Nile flood-water and fertilized by its mud. This system was and is still very favourable to the two most profitable crops, cotton and sugar—the cotton being a summer crop requiring nearly eight months for its growth, and the sugar cane being a crop which will grow all the year round with irrigation. But Egyptian agriculture has been revolutionized through the modern system of scientific irrigation gradually introduced into Lower Egypt during the 19th century, the object of which was to provide a well-planned network of main and subsidiary canals, and to substitute a carefully organized system of perennial but limited watering instead of the old six weeks of heavy flooding; and this improved modern system of perennial irrigation has been of immense benefit to the country, both financially and otherwise. One result of this may be noted in the rapid annual increase now taking place in the population, and another is that the comfort and the whole standard of living among the peasantry are far higher than formerly.

By supplying limited quantities of water to agricultural land, new crops could be grown without ever being inundated and damaged. Summer (*Sefi*) canals were dug to receive and distribute the Nile water during the shallow season, and were of course dug deeper than the flood (*Nili*) canals. These summer canals now permeate the whole of the delta forming Lower Egypt. By means of careful protection against prolonged inundation, and of feeding the land with small quantities of water whenever required and all the year round, so as to permit of cultivation in summer as well as in winter, these perennial irrigation canals have added vastly to the agricultural capability and wealth of this the richest part of Egypt. But against this great advantage there is the serious drawback that, while the new system of double-cropping takes more out of the land than formerly, the new irrigation puts less fertilizing matter into it, so that land devoted to cultivating exhausting crops like sugar and cotton gradually decreases in natural fertility. This inevitably leads to soil-deterioration, that can only be prevented by artificial manuring or by inundating the land periodically with the muddy flood-water, as was previously customary under the old 'basin' system of irrigation during the flood season. When this new perennial system of irrigation was introduced in a partial and incomplete form about eighty years ago by Mahomet Ali, the watering for summer cultivation was not accompanied by any proper system of drainage, and this hastened the deterioration of the soil, and gradually ruined large tracts in the lowest part of the delta adjoining the great lagoons—this northern portion having once been one of the most fertile parts of Egypt. Hence it converted them into swampy uncultivable salt marshes, that latterly have been in process of reclamation by means of a thorough washing of the soil, accompanied by proper drainage, and by rice cultivation on a restricted scale, owing to dearth of summer water. But even to the ancients the beneficial and cleansing effect of rice cultivation appears to have been taken advantage of in these tracts.

Under the new system of improved perennial irrigation the canals have to be carefully laid, to be well supplied with regulating sluices judiciously placed, and to be cautiously worked. And this irrigation system has to be accompanied by an equally well-planned and well-regulated drainage system for drawing off the water when no longer beneficial to the land—for, being strongly impregnated with salt from the soil, this water can only be injurious if allowed to remain. In fact, just as in animals the circulating system provides both for a continuous flow of reoxygenated arterial blood and also for the withdrawal of deoxygenized venous blood, so, too, must the modern perennial irrigation system of Lower Egypt (greatly improved and practically revolutionized since 1883) provide both for an ample water supply being conveyed to the fields, and also for its withdrawal when the full benefit has been obtained and only harm can be expected by its being allowed to remain longer.

Even when the present system of summer cultivation was first introduced, it was seen that complete success mainly depended on damming up the Nile at the apex of the delta. The first attempt to erect a *barrage* (1833) failed, but in 1842 a big dam was built about 14 miles below Cairo, spanning the two branches of the Nile just

below where the river divides into the Rosetta and the Damietta branches. The water for the irrigation of all that part of the delta lying between the two great branches of the Nile is supplied mainly by the great Menufia Canal. The arches of each bridge were constructed so as to permit the free flow of the water when high, but on the fall of the river they could be closed by iron gates in order to raise the river level above the dam and store up the water for irrigation purposes, and thus form a great reservoir for supplying the three main canals intended to irrigate the eastern, the central, and the western provinces of the delta. This barrage was not completed or rendered efficient until large works were carried out from 1883 to 1890, since which time the whole of the delta and all that part of Egypt to the north-east of Cairo and the south of Zagazig have been made entirely independent of the temporary level of the Nile. And at the same time the 'basin' system of irrigation to the south of Cairo has been greatly improved by arrangements which allow the water in basins belonging to a group in one part of the valley to be supplemented during a low flood by the inflow of water through canals led from the next group higher up. A similar *barrage* has been constructed in the upper Nile valley at Assiut, where the great Ibrahimiyeh Canal strikes off to the left of the river; and a great dam has been built at Assouan (completed in January, 1907) for raising the water-level and forming a great reservoir for the irrigation of agricultural land. Work is now in progress for heightening the Assouan dam by 16 ft., which will more than double its storage capacity, and will give sufficient extra water to irrigate during summer nearly one million acres now lying waste in the northern tracts of the delta. Another *barrage* begun at Esneh in 1906 is now being completed (1908), and will add largely to the area of perennially irrigated land.

Both in Lower and in Upper Egypt the most valuable crops are cotton, sugar cane, maize, millet, dates, rice, which all require a high temperature, and some of which take long to ripen, so that water is now needed all the year round from the perennial canal system. Indigo and tobacco are cultivated to a small extent, although Egypt is dependent on imported tobacco as the raw material for its cigarette industry.

Crops.	1st year.	2nd year.	3rd year.
1. Cotton	March to October.		
2. Clover (7 cuts)	October	to July.	
3. Maize (2 crops) and 4. Wheat (or clover, 2 cuts)		July	to February.

COTTON is, however, by far the most important crop financially, as raw cotton and cotton seed are the great staple products, forming nearly nine-tenths of the entire exports, which aggregated £28,000,000 sterling in 1907. Cotton cultivation extends from March to the end of October, and is immediately followed by clover, of which seven cuts are taken. To the cultivation of this clover (Berslem) the maintenance of the fertility of Egyptian soils is largely due. During the next twenty months from the following July onwards, two crops of maize and one of wheat may be reaped, the wheat being grown in winter and spring; or the second crop of maize may be followed by clover, from which two cuts are taken before the soil is again cleared for the recommencement of cotton cultivation in March.

This may be taken as a typical example of the ordinary three years' rotation in the delta under the modern system of perennial irrigation. The rich soil gives an average yield of about 500 lb. of cotton per acre, which is higher than the production in America. For the most part the crop is not manured, although experiments show that the yield can thus be increased to about 700 lb. an acre. Gradually, however, the practice of top-dressing is coming into practice, as the cultivators are beginning to see that it is profitable. The cotton produced is of the first quality, and commands the highest market price. Its superior quality is due partly to the soil fertility as to mineral composition and partly to the favourable climatic conditions under a bright sky and a temperature that rises and falls with great regularity while the crop is growing and ripening. In the delta these conditions are more favourably combined than throughout Upper Egypt, where the cotton has not the same strength of fibre as that grown in Lower Egypt. The largest production of cotton took place in 1906 and 1907, when the total yield amounted in each year to about 315,000 tons. In 1907 the area under cultivation was generally increased, and up to the end of the flood season prospects were so favourable that a yield of about 350,000 tons was expected; but climatic conditions afterwards became unfavourable, and the total crop was about the same as in 1906, which had been the largest on record. The average yield per acre in the delta appears to be decreasing, however, as is shown from the following statistics prepared by the Khedivial Agricultural Society:—

Triennial periods.		Average yield per acre.
1895–1897	......	500 lb.
1898–1900	......	450 ,,
1901–1903	......	435 ,,
1904–1906	......	385 ,,

The main causes of this diminution are the pernicious practice of overcropping induced by the present high price of cotton, and the deterioration in the quality of the seed used; but it may also partly be due to a rise in the level of the subsoil water in places where there is in-

sufficient drainage. This very important question is now being considered in all its bearings by a committee of agricultural experts.

WHEAT has always been the chief cereal, other important crops being barley, maize, great millet (*durra, sorghum*), beans, lentils, &c. In the cultivation of each and all of these very little trouble is taken beyond the careful management of the irrigation water. The area under wheat in 1906 was 1,219,082 ac. (622,833 in Lower Egypt, and 586,249 in Upper Egypt), and the production varies from $21\frac{3}{4}$ to $24\frac{1}{2}$ bus. per acre. An effort is now being made to improve the crop by introducing strong wheat fit for export, but the total quantity at present produced is not sufficient to supply the internal requirements of the country with its eleven millions of inhabitants. Hence a high yield is of great importance, then a heavy straw crop; and immunity from rust is essential. Many foreign wheats fulfil these three requirements, but unfortunately none of them thrive in the dry Egyptian climate, which seems suitable only for the Indian and Algerian wheats. Experiments with new varieties of Russian and American spring wheats have given a heavy yield, but these are too late in maturing, and are too short in straw; so experiments are now being made to cross these heavy-yielding varieties with Indian wheats maturing early and giving long straw. In Egypt a good crop of Indian wheat compares favourably in value with a moderate cotton crop; and there is this great advantage, that the trouble in cultivation and the risk of loss through insect attacks are far less with wheat than with cotton, while the two can be grown on a three-year rotation without prejudice to either. Hence the Nile valley has great capabilities for wheat production in sufficient quantity to make Egypt entirely self-supporting as regards this necessary grain, which has at present to be imported to a large extent.

Agricultural Live Stock comprises in cattle the strong draught native oxen of mixed race, and the Indian Water Buffalo, used for draught purposes and prized for its rich milk. Mixed flocks of sheep and goats abound in every village, while asses are numerous and are universally kept by the *fellah* for riding and other purposes. The camel is used solely for freight. Nearly all the ploughing and cultivation are done by oxen; but good working cattle are very scarce and dear, owing mainly to the absence of natural pasture.

The Department of Agriculture and Technical Education, recently organized, comprises two sections, one of which is charged with directing and developing existing technical institutions, and the other with building and organizing new schools. The chief agricultural instruction is given at the central School of Agriculture at Ghizeh.

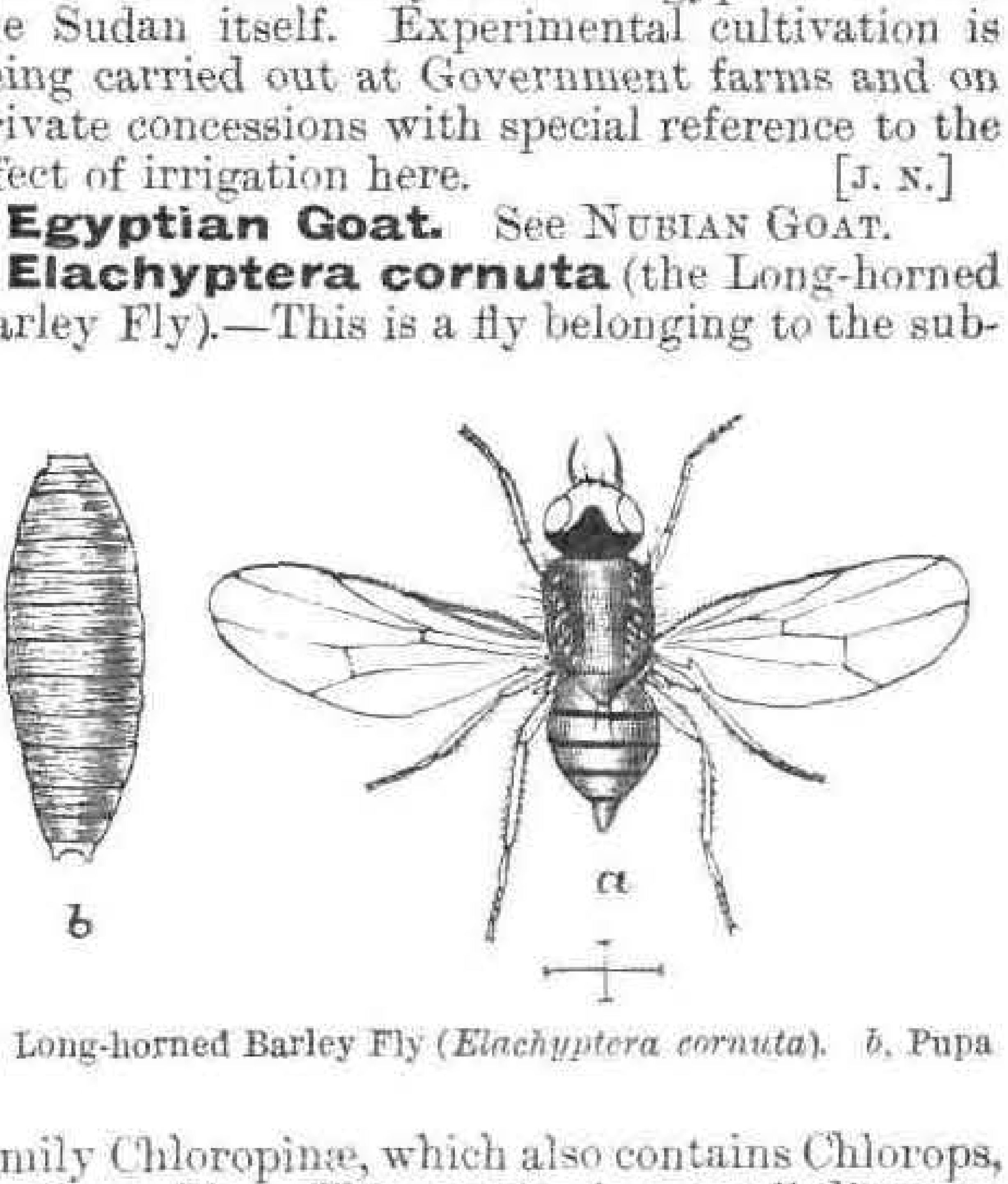
The agriculture of the *Sudan* may be here briefly referred to. The northern portion is entirely dependent on irrigation, while farther south the rainfall occurs more frequently and is more abundant. To the south of lat. 10° N. plentiful summer rains convert the low plains bordering the White Nile and the Bahr el Ghazal into great swamps. Though these extensive undrained plains are unhealthy the soil is fertile, and vast areas are suitable for growing cotton, oil seeds, indigo, tobacco, and other tropical products, the cotton being of high quality. Considerable progress in agriculture has already been made during the last eight or ten years, and the areas now under cultivation are as follows:—

	1906. acres.	1907. acres.
Artificially irrigated	116,773	120,760
Rain crop	796,628	1,186,514
Flood	95,241	116,697
Total ...	1,008,642	1,423,971

Egyptian cotton is here gaining ground, and the crops realize exceptionally high prices owing to their fine quality. Though the export (by means of the railway from Berber to Port Sudan and Suakin on the Red Sea) was only about 1750 tons in 1907, yet this is a large increase on the previous year's export. Cereals appear to be the crops on which any immediate trade development is most likely to depend. Surveys are now in progress for the construction of irrigation works on both the Blue and the White Nile, which will ultimately benefit Egypt as well as the Sudan itself. Experimental cultivation is being carried out at Government farms and on private concessions with special reference to the effect of irrigation here. [J. N.]

Egyptian Goat. See NUBIAN GOAT.

Elachyptera cornuta (the Long-horned Barley Fly).—This is a fly belonging to the sub-



a, Long-horned Barley Fly (*Elachyptera cornuta*). *b*, Pupa

family Chloropinæ, which also contains Chlorops, the Gout Fly. This species is a small dipteron about 3 mm. ($\frac{1}{8}$ in.) long, shiny-black in colour, with two rather broad grey stripes on the fore body, and a shiny blackish-brown abdomen. Head reddish-yellow, with a large black triangular mark on the crown; antennæ reddish-yellow, with black bristles. Legs yellow, with darker feet and median markings on the tibiæ and femora.

The maggots live in barley straw and cause swellings at the base, the enlargement being far less than that caused by the Gout Fly, and the plants seem to grow away from the attack. They pupate between the sheathing leaf and haulm. The brown puparia show evident traces of tail spiracles on prominent paired processes which were present in the larvæ. Flies hatch in September, and apparently lay eggs on wild

grasses. The pest is recorded from Ireland (Carpenter). Burning refuse from an attacked crop is an obvious preventive measure. [F. V. T.]

Elæagnus, a genus of evergreen or deciduous shrubs of the nat. ord. Elæagnaceæ. They are known as wild olives, and some of them are grown in gardens, as they make shapely bushes; the leaves are generally decorative, the flowers are usually very fragrant, and the fruits of some are bright in colour and edible. The following are the best known: *E. glabra*, which has ovate-oblong evergreen leaves, rust-coloured below, and of which there is a variety with prettily variegated leaves; *E. macrophylla*, with roundish ovate, rather large leaves, clothed with silvery scales, and in autumn the scarlet fruits are attractive; *E. pungens*, the well-known Japanese shrub, which sometimes grows to a height of 10 to 12 feet; its leaves are oblong and undulated, and silvery on the under surface, and there are varieties with gold and silver variegated leaves. These plants grow exceptionally well in poor sandy soil, and are therefore excellent for seaside gardens. [W. W.]

Elateridæ, a family of beetles popularly called 'click beetles' or 'skip-jacks'. They are the parents of the wireworms. Their distribution is very wide, most countries having various kinds of wireworms destructive to crops. A number of species occur in Britain, but only a few are injurious (see AGRIOTES LINEATUS, ATHOUS HÆMORRHOIDALIS, &c.). All the adults are capable of leaping, having a special apparatus beneath their thorax to enable them to do so. The shape is very similar in all this family, the wing cases lying over the body completely covering it and being pointed, so that when they are closed over the wings the general form of the body is lanceolate. The fireflies of the Tropics are also included in this family. [F. V. T.]

Elbow. See CAPPED ELBOW and FRACTURES.

Elder (Sambucus) is a genus belonging to the Caprifoliaceæ or Honeysuckle family. Its nearest relative, however, is the Guelder Rose (Viburnum), from which it is easily distinguishable in having pinnate foliage, and not entire or palmately lobed leaves. The generic name is taken from the Greek *sambuca*, a musical instrument, as the hard woody substance of the shoots and branches formed reed-like pipes on the large soft pith being extracted. The genus consists of small trees and shrubs with opposite pinnate leaves and large cymes of numerous, rather small, white flowers, in which the calyx is bordered with five small teeth and the corolla has a very short tube and five spreading divisions, at the base of which the five stamens are inserted, while the sessile stigma is three- to five-lobed. Its fruit is a berry-like drupe with three (rarely four) seed-like stones each containing one seed. Two species are indigenous to Britain, the Common Elder (*S. nigra*), also known in Scotland as the Bourtree-bush, and the rarer Dwarf Elder (*S. Ebulus*) or Danewort. In addition to these, however, the Red-berried Elder (*S. racemosa*), a Continental species common throughout the woodlands and mountains of Central Europe, is cultivated in shrubberies for ornament. The two native species are easily distinguishable by their leaves, ovate and non-stipular in the common species, and lanceolate and pseudo-stipular in the dwarf species.

The Common Elder is a large shrub or small tree having the stems and branches full of pith;

Common Elder: Foliage, Inflorescence, and Fruit

glabrous pinnate leaves with five to seven very shortly stalked ovate or roundish leaflets without stipular lobes, and generally acuminate and finely and closely serrated; flowers in cymes 5 to 6 in. broad, with five principal branches, and forming large, terminal, whitish or cream-coloured masses with an unpleasant odour, which ripen in September into small black berries. The somewhat purgative leaves are used for distilling elderflower water, and the berries used to be cultivated (Kent) for wine-making—a Scottish practice also, as immortalized in the celebrated song 'The Laird o' Cockpen'. As a woodland tree it has little or no economic value, and is usually regarded as a weed occupying spaces where other undergrowth would be more profitable. But it grows freely wherever there are open spaces in woods, coppices, and waste places; and it is often to be found growing

wild in hedgerows or planted in shrubberies. There are several varieties, the chief being var. *laciniata* with deeply and finely cut segments to the leaves. The Dwarf Elder is a coarse, herbaceous, fetid-smelling shrub of 2 to 3 ft. high with a short perennial stock, and thick, pithy, erect, annual, slightly branching stems, and seven to eleven lanceolate leaf-segments 2 to 4 in. long, with a small one on each side of the leaf-stalk, on the stem itself, looking like stipules. The cymes are smaller and less regular than in the common species, and have only three primary branches, while the flowers are sweet-scented and white or tinted with purple on the outside, and the fruits are black. Every part of this plant is very purgative and emetic, and cattle do not eat it; and where the leaves are strewn, mice and moles avoid the places. This shrub is most often met with on roadsides and in waste and stony places, but it has no commercial value. [J. N.]

Electricity.—There are many substances which when rubbed with other substances acquire a property they did not possess before,

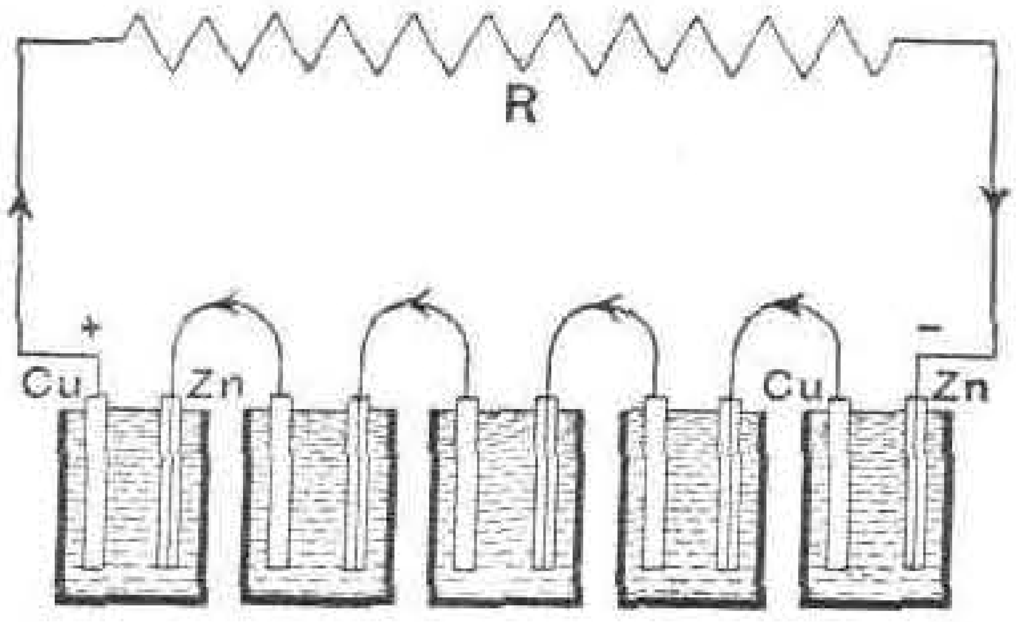


Fig. 1

namely, that of *attracting* and of being *attracted* by every substance in its ordinary state. Thus a glass rod rubbed with silk, and a stick of sealing wax rubbed with fur, have the power of attracting such light substances as chaff, down, and bits of paper. Such power of attraction is said to be due to *electricity*, and the bodies possessing it are said to be *electrified*. What electricity really is, however, has not yet been determined; but, like heat, it is known to be simply a 'form of energy', and not a substance. Apparently there are two kinds of electricity, for if two glass rods rubbed with silk be brought near together they repel one another; so also will two sticks of sealing wax which have been rubbed with fur; but if one of the electrified glass rods be brought near to one of the sticks of sealing wax they will attract one another. Hence, from these opposite effects, the glass rod and stick of sealing wax are said to be charged with opposite kinds of electricity; the charge on the former being called positive (+), and that on the latter negative (–) electricity. There are many other ways of generating electricity besides the above, and of these the more important are: (1) by chemical means; (2) by induction. When a sheet of zinc and a sheet of copper, for example, are partially immersed in acidulated water contained in an open vessel, we obtain what is called a galvanic cell, in which the exposed end of the copper becomes charged with + electricity and that of the zinc with – electricity. Further, when the exposed ends of these metals are connected by a piece of wire, an electrical current is established (which is supposed to flow from the copper to the zinc outside the fluid and from the zinc to the copper through the fluid) and maintained by the chemical energy of the zinc, a portion of which is dissolved in the process. If instead of having only

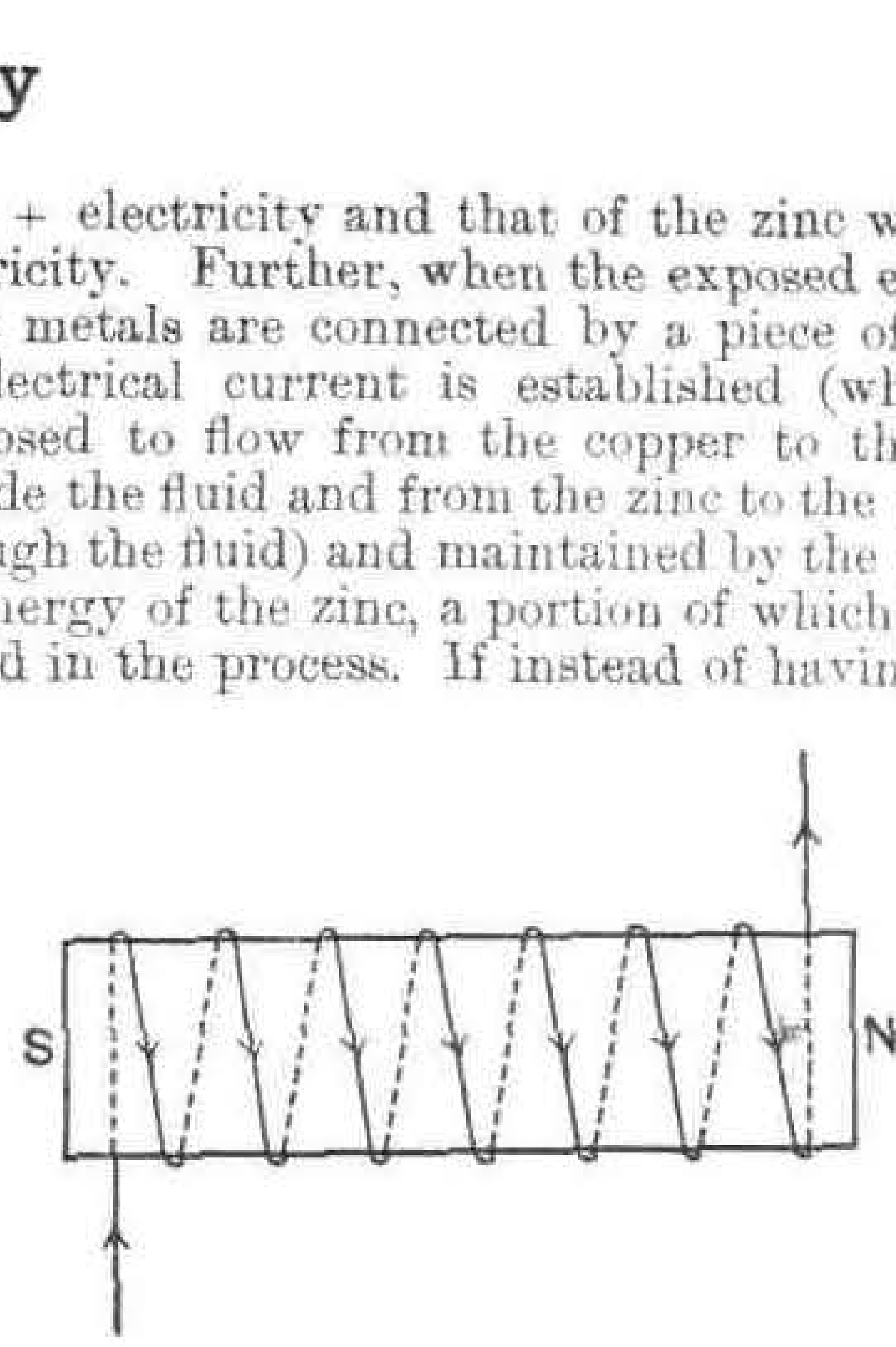


Fig. 2

a single *galvanic cell* we have a number of such cells joined together in series, thus forming what is called a *primary* or *galvanic battery*, as shown in fig. 1, a much stronger current would be obtained. The existence of this current, of course, can only be inferred from its effects, and these may be observed as follows: (1) If the terminals of the battery—the copper of first cell and the zinc of the last—be connected by a wire, this wire will soon get quite hot and may even be melted. (2) If the wire be broken and the loose ends brought near together, a spark will pass between them. (3) If the wire be coiled round a bar of soft iron, as shown in fig. 2, the bar will become a powerful electromagnet; but should the current be broken or

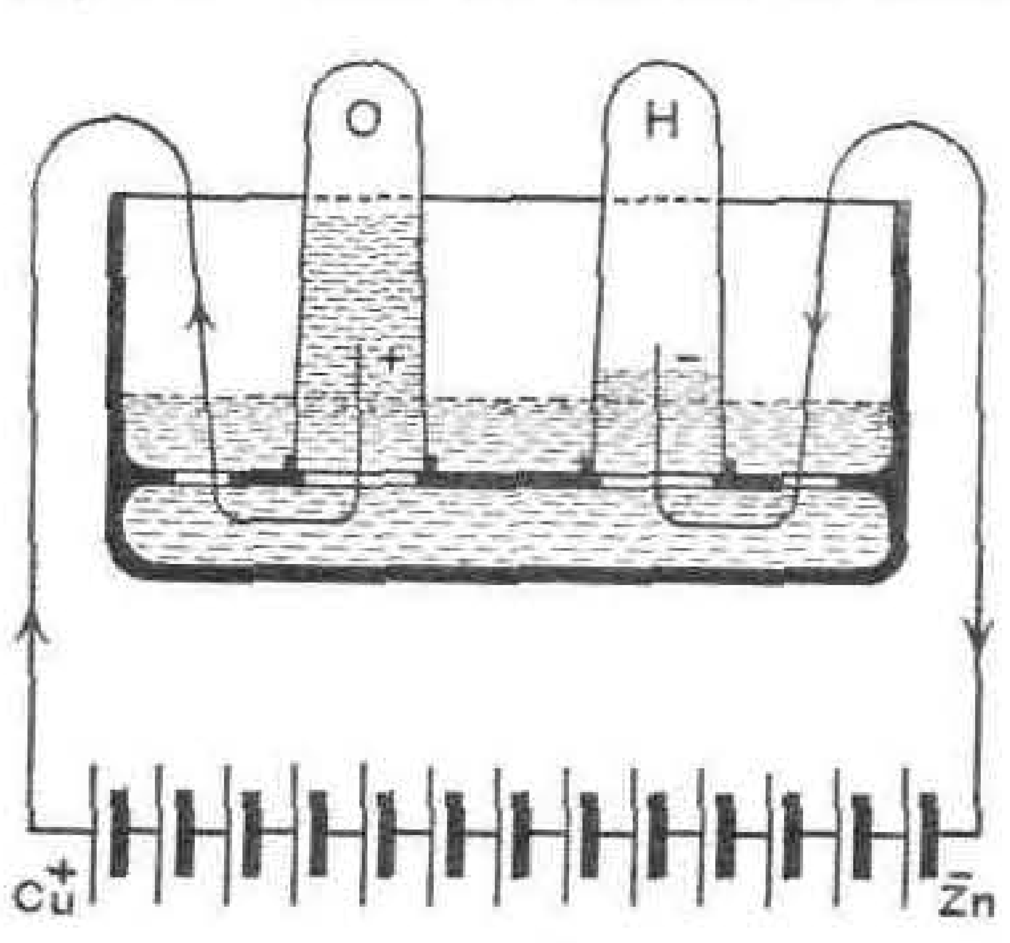


Fig. 3

stopped, the bar would lose its magnetism at once. (4) If a compass be brought near the wire through which the current is flowing, the needle will be deflected and tend to set itself at right angles to the wire. (5) If the wire be broken and the two loose ends immersed in acidulated water, the water will appear to boil. This is due to the water being split up by the electrical current passing through it into its gaseous elements of oxygen and hydrogen, which may be collected together or separately by placing test tubes full of water over the ends of the

wire, as shown in fig. 3, when the evolved gases will collect in the tubes, displacing the water.

The amount of electricity which can be generated by rubbing or friction, or by means of galvanic batteries, is comparatively small, and is suitable only for such purposes as electric bells, telephones, and telegraph instruments. When large quantities of electricity are required, as for purposes of lighting and the transmission of power, it is generated by means of electromagnetic induction. In 1831 Faraday discovered that when a long bar magnet, M, was rapidly inserted in a closed coil of insulated wire, W (fig. 4), a momentary current was

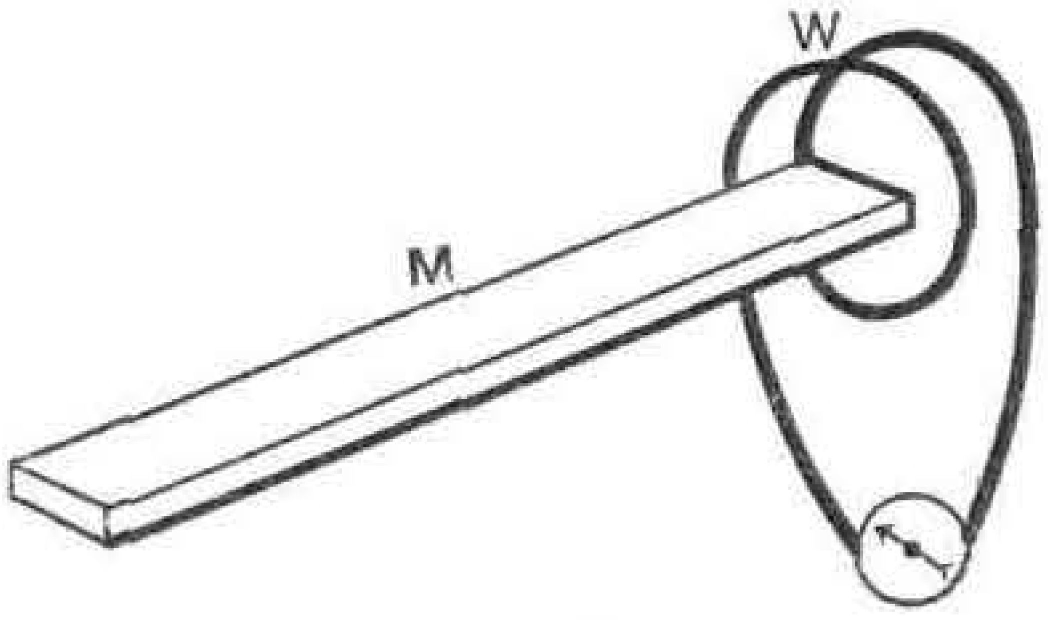


Fig. 4

induced or set up in the coil, and that when the magnet was rapidly withdrawn again, another momentary current was induced in the opposite direction to the former. It was thus rendered evident that a pulsating or alternating electrical current could be generated in a closed conductor by moving it rapidly backwards and forwards in front of a pole of a magnet, but as reciprocating motion is objectionable from a mechanical point of view it was suggested that the conductor be mounted upon an axis and rotated between the poles of a horseshoe magnet. Faraday's discovery thus led directly, first to the invention of the magneto-electric machine, and afterwards to the invention of the alternator and the dynamo, which are now used so extensively for generating electrical current for purposes of lighting and the transmission of power. See DYNAMO and MOTIVE POWERS. [H. B.]

Electricity, Effects of on Plant Growth.—It is not proposed to discuss in this article the possibility of applying electricity as a motive power for agricultural machinery, but only its application as a stimulus to either accelerate the growth of a plant or increase its productiveness. It has been applied to this end in many different ways. Usually the attempt has been either to obtain a small electric current passing through the plant, or to obtain additional chemical activity in the leaf by supplementing the hours of daylight with electric light; both applications have to be regarded as at present in the experimental stage. These two methods will be dealt with in turn.

1. AN ELECTRIC CURRENT PASSING THROUGH THE PLANT.—Two different methods of utilizing the current may be distinguished—in the one set of experiments the current passes through the soil, and presumably through the roots of the plant as well; in other experiments the current passes from strongly charged overhead wires down to the leaves of the plant, and then through the tissues to the roots and to the soil.

(*a*) Various methods have been used to obtain and apply the current to the roots of the plant. In many of the early experiments a system was adopted which is known in France as the Geomagnetifere. In this method an electric charge is accumulated by means of an erect metallic rod, practically a lightning conductor, with the usual group of metal collecting points at the apex; this conductor is connected with a system of underground wires which ramify under the roots of the plants undergoing stimulation. Many observers have described results, usually favourable, obtained by means of this system, but it has never been generally adopted in spite of its inexpensiveness. From the experimental point of view it has the disadvantage that the actual current flowing between the conductor and the soil will be very variable and not capable of measurement, while its distribution round the roots of the plant will be quite unknown. Another even cheaper method of obtaining a current is to sink in the ground two plates of different metals; in small-scale experiments copper and zinc have been used, on a large scale copper would be replaced by a cheaper material. When these two plates are joined by a wire they form practically an earth battery, and a small electric current will flow continuously through the wire. On wet days, if the plates are not too far apart, through the wire joining the plates probably many milliamperes will be flowing, and this means that the same amount of current is flowing through the earth from plate to plate. Rawson and Le Baron have recently tried this method under probably the most suitable conditions, viz. with the artificial soils of forcing beds. They apparently found it very efficacious, the lettuce so treated being ready for market a week earlier than lettuce similarly forced but not electrified. For use upon a large scale as required in agriculture, the current from such an earth battery would not be sufficient; the plates would need to be placed far apart, and then kept at very different potentials by means of a powerful dynamo.

(*b*) When the method of overhead charged conductors was first used, the necessary charge was obtained from the atmosphere—one series of points on an insulated metal conductor collecting the charge from the atmosphere, while another series of points, also carefully insulated and connected to the former by some flexible conductor such as a chain, redischarged it upon the plants. But in the later and better forms of apparatus a machine has been used to charge the overhead system of wires to a higher potential. Lemström made a number of experiments upon these lines, and largely at his instigation apparatus for this purpose has been tried by several workers in different countries. In these experiments the electrical apparatus consisted of a static influence machine driven by a motor or water power. From one pole of this machine the overhead system of wires was charged, the other pole was connected to earth, the circuit then was completed by a discharge from the overhead wires carried through the air to the

plants and then through the plants to the ground. Lemström's experiments show in many cases marked increases in the crop yields, particularly when the overhead system was charged positively, but they also render it very obvious that a fuller understanding of the effect produced by electrification is necessary before the method can be at all generally applied. Thus prolonged electrification in dry weather may be very deleterious, also different crops give entirely different results; for instance, in one case strawberries and beans were similarly treated, but while the strawberries showed a marked increase, the beans showed a decrease in yield. Chemical analyses of the crops showed that changes had been produced consequent upon electrification; perhaps one of the most significant was the higher percentage of sugar found very generally.

In comparatively recent times J. E. Newman has introduced a new method of charging the overhead system of wires, which renders the method more applicable upon a large scale. By means of a large coil the current from a dynamo is raised to a very high potential, and then by means of electrical valves, of a type recently patented by Sir Oliver Lodge, the oscillatory nature of the discharge is removed, and it is possible to give continuously to the overhead wires either a positive or a negative charge. With such an apparatus, during 1906 and 1907, some 20 ac. of ground have been under electrification, and the trials are still (1908) in progress. The results so far have borne out the earlier work of Lemström and others, the two main features distinguishing the electrified crops being the acceleration and the increased yield.

Thus in 1906, with some 12 ac. of wheat under electrification and some 7 ac. of the same field unelectrified, the following results were obtained:—

Bushels per acre.	Electrified.	Non-electrified.	Increase.
Canadian Red Fife ...	35½	25½	39%
English White Queen	40	31	29%

The electrified Red Fife was ready for cutting some five days earlier. In 1907 the results with wheat were as follows:—

Bushels per acre.	Electrified.	Non-electrified.	Increase.
Canadian Red Fife ...	41·4	32	29%

One exceedingly convenient point about this method of electrification is the height to which the overhead system of wires can be raised, as owing to the high potential at which they are kept, effective discharge still takes place from the thin wires intended for the purpose. The wires in Newman's experiments at Evesham were raised 15 ft. above the ground, so that it was possible to carry on all necessary work amongst the growing crops, and later to harvest them, without making any alterations in the electrical installation.

It is obvious that the results given above represent considerable financial gain, especially when it is remembered that the increased yield is accompanied by accelerated production. It is impossible at present to speak definitely on the financial side, but while the initial cost of such an apparatus as that used by Lemström, or the much better one used by Newman, is necessarily considerable, the running cost in either case is only the motive power, probably either an oil or gas engine. From recent trials made on a station at Bitton, near Bristol, the apparatus as used by Newman is able to run for long periods without skilled attention, and it seems probable that further work along these lines would make its addition to the wages bill on a large farm comparatively small. Another point, however, that does not lead to economy is our ignorance as to the exact physiological effect produced by the current; until this point is ascertained its application can only be empirical. Exact information on this point is not yet forthcoming, though various theories have been advanced. Lemström himself was of the opinion that the rise of sap through the plant was accelerated by the current, and more recently Chundar Bose advances the same theory, and states that it permits of experimental verification. Other suggestions refer to a chemical action upon the part of the current, in particular the amount of sugar in the plant seems to be greatly increased; the total increase of sugar in the roots of the sugar beet, taking account of the greater weight of roots pulled, being very striking. These facts are in line with the recent suggestion of Pollacci, again based upon experimental work, that the current enables the plant to synthesize sugar and starch in a light too weak for such synthesis under ordinary conditions. Confirmation of this result would suggest that the current should be applied preferably in the early morning and in the evening. Berthelot states that under discharge he has found the plant, and also indeed many dead organic bodies, capable of absorbing and apparently chemically retaining the nitrogen of the atmosphere. It was noticeable in Newman's experiments in 1906 that the electrified plants were of a darker green, as is often the case with plants well supplied with nitrogenous manure.

2. Electric Light as a Stimulus.—Along this line, Siemens was one of the pioneers in England, and Dehérain in France. They both came to the conclusion that without the interposition of a glass screen to cut off the ultra-violet rays, the light is prejudicial to healthy growth; but with this precaution Siemens found that using the arc light in addition to the normal hours of daylight, he obtained an increased and accelerated yield from his crop as a rule.

C. H. Bailey experimented upon the subject for some years at Cornell University and noted this same acceleration. He found that, generally, better practical results were obtained using artificial illumination for half the night only. With these conditions, lettuce in particular showed a marked acceleration, being ready for market in some cases a month earlier, while other crops did not give such good practical results, showing a tendency to run rapidly to seed. These experiments have one analogy with those of Lemström, in that it was found that regular and

copious watering was essential for the best results to be obtained. Without this precaution, a dry season, even a brief one, often leads to disastrous results.

It is evident, then, that while much good pioneer work has been done, much still remains to be done before the application of electricity in agriculture upon the large scale becomes an accomplished fact. [J. H. P.]

Eleocharis or **Heleocharis** is the name of a genus of cyperaceous plants commonly called

Creeping Spike Rush (*Eleocharis palustris*)

Spike Rushes. The genus is marked by the roundish stem terminating in a single spikelet of flowers. The commonest species is the Creeping Spike Rush (*Eleocharis palustris*), which is usually found filling up bog holes and ditches. The plant is composed of a long and extensively branched underground stem of a black colour. From this the green grassy-looking parts rise up into the air. Some of these green parts are leaves, and some are stems on which the leaves are rudimentary and reduced to brown sheaths. At the water edge the stem is only 6 in. high, but when growing in the water it may become twice as high. The solitary spikelet terminating this stem is ¼ or ½ in. long, and is composed of overlapping brown scales which conceal the minute flowers.

On heaths and moorlands a closely allied wiry plant called Scaly Club Rush or Deer's Hair (*Scirpus cæspitosus*) is very common. It is tufted rather than creeping, and the stem leaves are sheaths tipped with a short green blade, not mere sheaths as in Creeping Rush. See SCIRPUS. [A. N. M'A.]

Elephant.—The Indian elephant has long played an important part in the life of Eastern nations. Used at first for war and for State pageants, its extreme teachableness and great strength led to its being employed for many other purposes, such as road making, bridge building, jungle clearing, and the like. For 'the elephant's tusks and trunk serve at once as lever, screw jack, dog hooks, and crane . . . and his head, protected by a pad, is a ram of immense force, and superior handiness'. It is, however, expensive, for it requires about 800 lb. of green food in twenty-four hours to keep it in health, and this, with the wages of its driver, costs from £5 to £8 per month according to locality. It is also delicate; its skin chafes readily; it becomes footsore and is difficult to heal, and it is subject to inflammation of the eyes. For these reasons, wherever railways and made roads have penetrated, its use is being superseded by steam machinery. But in inaccessible districts it still retains its importance. For the transport of agricultural produce, military stores, &c., it is invaluable, for it can carry a load of 800 lb. over rough or even marshy ground for eighteen or twenty miles. Much heavier loads can be carried for shorter distances. In the timber yards of Burma the elephant is used for piling heavy logs, and it shows much dexterity in moving them, sometimes with the aid of ropes held in the mouth, sometimes edging them on to its tusks and keeping them in place with its trunk. This latter organ, however, being 'as vulnerable as a garden slug', is used with extreme caution.

In the tea gardens of Assam and Ceylon the elephant's aid is almost indispensable. In rooting up bushes, and clearing away thick tangled undergrowth to prepare the ground for planting, it is without a rival. It is sometimes even yoked to the plough, but it is not well suited for continuous draught work.

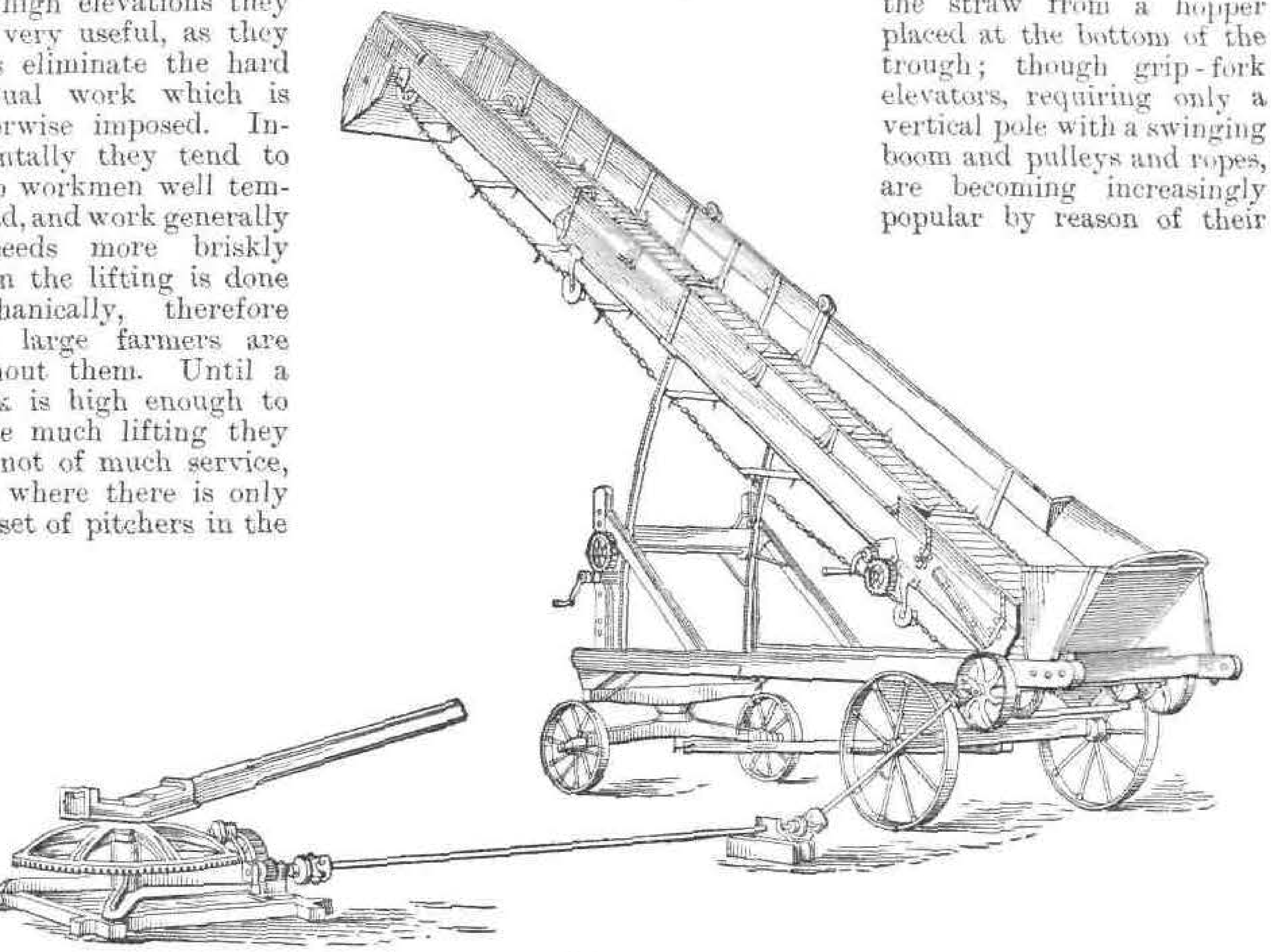
The African elephant is less tractable, and there are some authorities who doubt if it was really this species that was used in war by Hannibal and the Romans. It has recently been tried, with some success, for agricultural work in the Congo, but it is too soon to judge of results. Its numbers are being steadily diminished by unregulated slaughter for the sake of the ivory. [J. A. T.]

Elevation. See ALTITUDE and EXPOSURE.

Elevator Gear.—Elevator gear is ordinarily simple, as the main object is to provide for the circulation of the endless chain, and the minor ones are the raising of the trough and the tightening of the chain. The main spindle carries a pulley which is driven from a pulley on the threshing machine or from a lay shaft

of a horse gear, in the latter case being driven by a clutch on the spindle. On the opposite end of the spindle is an octagonal wheel, or a spurred wheel over which the links pass and are driven; at the top of the trough is a corresponding, but loose pulley, around which the chain circulates. Various devices are employed to raise the trough, but the most used is the worm and quadrant. [W. J. M.]

Elevators.—Elevators are mainly used to pitch corn, hay, and straw on to the stack, and for high elevations they are very useful, as they thus eliminate the hard manual work which is otherwise imposed. Incidentally they tend to keep workmen well tempered, and work generally proceeds more briskly when the lifting is done mechanically, therefore few large farmers are without them. Until a stack is high enough to cause much lifting they are not of much service, and where there is only one set of pitchers in the field many farmers prefer to find an extra hand or two and use a high trestle platform, to going to the expense of an elevator. Where, however, there are more than one set of pitchers, there is no doubt as to the advantage of using the elevator. The great drawbacks to the elevator are the cost, ordinary short life of the machine, the need for a horse or other motive power to work it. Nothing has been found to supersede the trough elevator with endless chains carrying crosspieces with forks which carry up the straw from a hopper placed at the bottom of the trough; though grip-fork elevators, requiring only a vertical pole with a swinging boom and pulleys and ropes, are becoming increasingly popular by reason of their smaller cost, particularly for hay stacking. Elevators should be lightly constructed consistent with strength; should be easily and safely raised and lowered; the means of tightening the links be simple; the trough be easily cleaned, and when lowered should fold into short length and not be too high, or the shed in which it is kept will have to be high. The elevator ought to last many years, but owing to exposure the trough is too frequently allowed to decay, this being encouraged by the dust and dirt allowed to accumulate, and then turned to mud when rains come. Comparatively new elevators may sometimes be seen with plants growing in the joints from this cause. Elevators on the trough principle are used to raise chaff, but scraping boards take the place of forks. Tubular elevators through which a strong blast is forced are also used to elevate chaff, straw, ensilage, &c. [W. J. M.]



Elevator

Elk, The, or **Moose** (*Alces machlis* or *palmatus*), is found in the northern parts of both the Old and the New World. In America it is still abundant, in Asia it is fairly numerous, but in Europe it is now rare, and is confined to Scandinavia and the Baltic Provinces. Even in these countries it would probably have become extinct had not legislative measures been taken for its protection. The Elk is the largest of all deer, sometimes standing 6 ft. high at the shoulders. The general colour is very dark reddish-brown, blacker on the mane, head, and breast. The legs are long and strong, the neck short and thick, the head ungainly looking because of the broad nose and the long, hairy, and very mobile overhanging upper lip. The antlers of the adult Elk form a broad, shovel-like expansion, with marginal prongs, which increase in number with each year of life. A head, that is a pair of antlers with the skull, is said to weigh from 40 to 70 lb. The female bears no antlers, but is as large as the male. The favourite haunt of the Elk is in thick and marshy forest, especially where birch and willow abound. It is usually solitary in habit, but in winter the males assemble in small troops. They are usually wary and unapproachable, but at the breeding season they lose their shyness and become exceedingly combative. The huntsmen

then sometimes decoy them within shooting range by imitating the challenge call of the male. The gait is a heavy-looking trot, but they make good progress, and are very enduring except in snow, when they can be run down by Indians on snowshoes. They feed on young shoots, leaves, and the like, and work havoc in the woods by breaking the crowns of fair-sized young trees to browse on the tips. In winter they subsist for the most part on lichens. One or two fawns are dropped in April or May.

In America this deer is called the Moose. The name Elk is there given to a different animal, the Wapiti (*Cervus canadensis*) of the Red Deer group. [J. A. T.]

Elkington, Joseph, a Warwickshire farmer who flourished in the latter half of the 18th century. He is chiefly famous for having devised an improved system of drainage which was specially applicable to land made wet by the bursting of springs. So successful was his system that the Government of the day granted him a reward of £1000 for describing the principles on which his practice was founded. His system was commended by the Board of Agriculture, and explained in the press by John Johnston, who published a book giving an account of Elkington's mode of drainage. It was also recommended to the notice of Scotch farmers by Stephens, himself a well-known drainer. Elkington's system of drainage continued to confer great benefits on British agriculture till about the year 1825, when it was superseded by other modes of drainage. For further particulars see DRAINAGE.

Ell, a measure of length originally taken from the length of the arm. The old English ell measured 45 in., while the Scottish ell was $37\frac{2}{10}$ in.

Elm (Ulmus) is the only European genus of the Ulmaceæ family, all the other seven genera being natives of tropical lands. As a genus it is characterized by being monœcious and bisexual, and by producing, before the leaves flush, groups of lateral flowers which form small, flat, oval, winged samara fruits having the seed in the centre. It is a widely spread genus, including several species in Europe, Asia, and America, varying in size from the lowly shrub, the Siberian Dwarf Elm (*U. pumila*), up to the English Elm (*U. campestris*). Three European species have been distinguished (*U. campestris*, *U. effusa*, and *U. montana*) in that originally denominated *U. campestris* by Linné; but the distinguishing characteristics of the first two appear so frequently interchangeable that, in Britain at any rate, only two well-defined species occur, the Common English or Small-leaved Elm (*U. campestris*), originally introduced by the Romans, but now for many centuries one of the commonest hedgerow and park trees throughout England, and the Mountain, Scots, Wych or Broad-leaved Elm (*U. montana*) indigenous to Britain, and occurring more frequently than the other species in the cooler climate of Scotland and Ireland. The English Elm is easily distinguishable from the Wych Elm by its rougher and more deeply fissured bark, its more formal slender shoots with very regular alternate buds, leaves, and twigs, and its smaller, less pointed, less deeply serrated, and less rough leaves. Botanically it also differs in having nearly sessile, closely tufted, four-cleft, brownish flowers appearing in March and April, and in ripening its oblong, deeply cloven, glabrous yellow fruits in May; whereas the Wych Elm has loosely tufted five- to six-cleft reddish flowers on longish peduncles, which appear in April and May, and ripen in June into roundish, slightly cloven, naked brown fruits. Arboriculturally the English Elm is the larger and more picturesque and graceful tree, though the Wych Elm forms a bigger and more spreading crown. But as park trees they both are liable to have their heavy branches torn off during gales, and even sometimes drop them in warm, windstill weather. Sylviculturally they also exhibit well-marked differences in Britain. A native of southern Europe, the thoroughly naturalized Common Elm even in the warmer parts of England only produces good seed in exceptionally warm years, but to compensate for this it is endowed with a very strong reproductive power in throwing up easily transplantable root-suckers as well as stool-shoots; and it is to this quality that it owes its prominent position as one of the commonest of English trees. Our indigenous Mountain Elm, on the other hand, grows more rapidly and produces seed abundantly from about the thirtieth

Common Elm (*Ulmus campestris*)

1, Fruits. 2, Flowers. 3, Leaves.

year onwards (which ought to be sown as soon as it ripens, as it soon loses its germinative power, comparatively low at best), but has not the power of throwing up suckers from its roots.

From ancient times Elm has always ranked as one of our best timber trees. In the Statute of Woods (1543) it is specially mentioned as one of the trees to be selected for standards in copse, in default of the more valuable Oak desired for shipbuilding; and among the underwoods it has always been a common, though not a valuable kind of coppice. The reddish heartwood of English Elm timber, strong in lateral fibre and of a rich reddish-brown colour, was in olden times along with Oak the chief furniture wood in England, and used to be largely used for water-conduits before the days of leaden, iron, and earthenware pipes; but its present use is chiefly for coffins. Wych Elm timber produced in the north of England and in Scotland is stronger and more durable, and is often used for carts, wheels, implements, and other rural purposes as a substitute for the still tougher and more elastic Ash. But throughout central and southern England the wood of the Common Elm usually fetches the higher price (up to about 1*s.* 4*d.* a cubic foot). For good growth the latter requires a warm climate and a good soil, and grows best on a deep sandy or medium loam and on fairly level or undulating land; while the Mountain Elm thrives in the moist but well-drained soil of glens and ravines in hilly tracts, the largest trees being usually found near streams. The cultivation of both species is easy, the common species being chiefly propagated by means of layering shoots or of cutting away suckers from their parent roots, and the Wych Elm mainly from seed sown in drills and very sparsely covered with mould immediately after the fruits ripen in spring. At best its germinative power is low (about 40 to 45 per cent), but storage weakens this, and often causes the seed to lie over inert for a year, and then to come up very thinly and irregularly. Seedlings are ready for transplanting in the following spring, and usually stand for two years in the nursery lines before being planted in the open (usually at about 4 ft. apart). [J. N.]

Elm.—Parasitic Fungi.—Wood Rot.—The well-known tendency of elms to shed large branches can frequently be traced to heart-rot caused by fungi. Several species of Polypores (see Fungi—'Polyporeæ') occur on elm. White rot of timber may be produced by the Tinder Fungus (see Beech, Parasitic Fungi) or by the Scaly Polypore (*Polyporus squamosus*). One form of red rot is particularly common in some districts, such as on calcareous sandy soils; the trunks are more or less hollow, and after felling, the heartwood shrinks in a star-shaped manner.

Treatment.—To preserve ornamental trees, all stumps or branch snags should be trimmed off close and dressed with tar in the autumn. On soils conducive to heart-rot, the trees should be felled off as soon as they show any signs of deterioration, and other species planted.

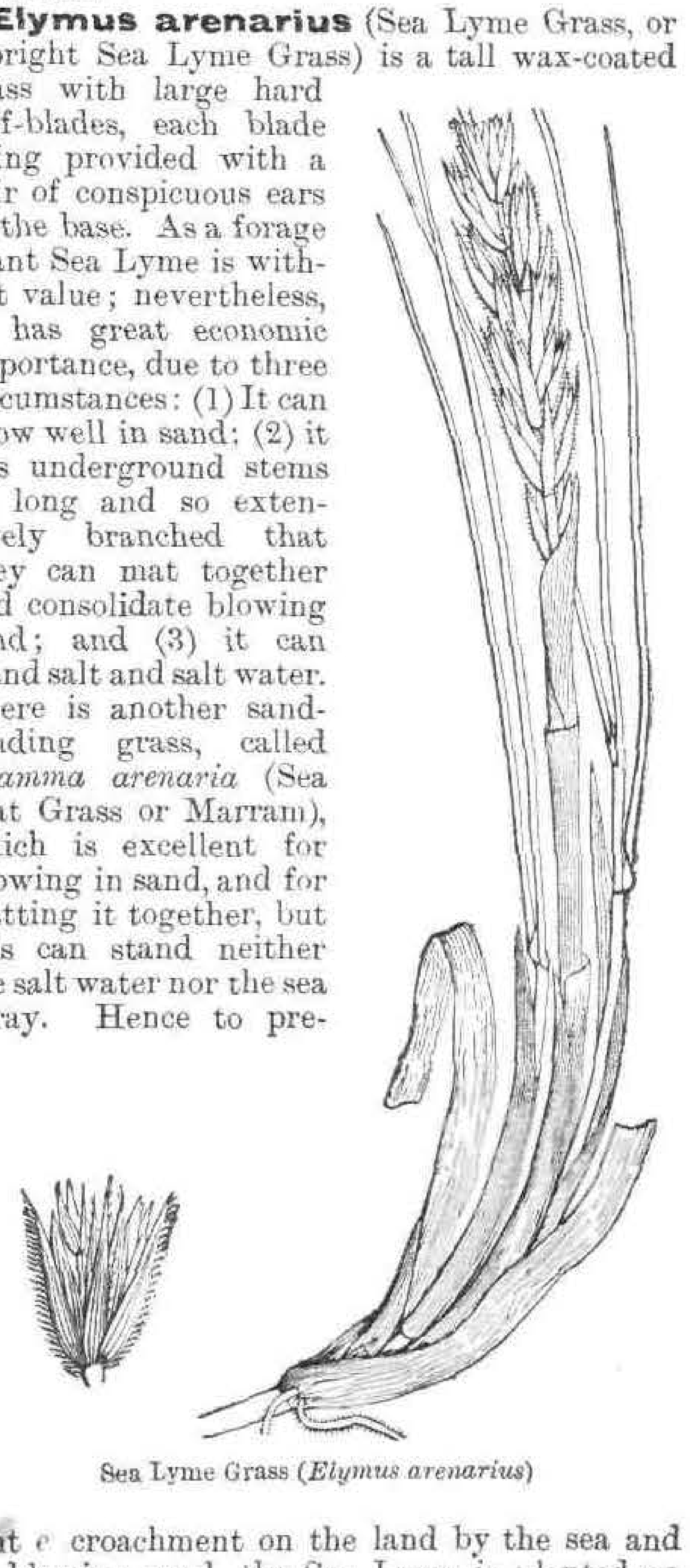
Slime Flux.—The emission of a slimy fluid from old wounds or cracks is frequently observed on elms, although it also occurs on other trees. The flux is most conspicuous during the spring; it is generally brownish and has a distinct odour. Yeasts, bacteria, and various fungi are present, which assist in keeping the wound open. Although the flux weakens the tree, it rarely kills it.

Leaf Spot.—A powdery mildew (*Erysiphe*) forms a white coating, and several other fungi produce discoloured spots. During the nursery period these may become serious, but most of them will be kept in check by spraying with Bordeaux mixture. See Fungicides.

[W. G. S.]

Elm Bark Beetle. See Scolytus destructor.

Elymus arenarius (Sea Lyme Grass, or Upright Sea Lyme Grass) is a tall wax-coated grass with large hard leaf-blades, each blade being provided with a pair of conspicuous ears at the base. As a forage plant Sea Lyme is without value; nevertheless, it has great economic importance, due to three circumstances: (1) It can grow well in sand; (2) it has underground stems so long and so extensively branched that they can mat together and consolidate blowing sand; and (3) it can stand salt and salt water. There is another sand-binding grass, called *Psamma arenaria* (Sea Mat Grass or Marram), which is excellent for growing in sand, and for matting it together, but this can stand neither the salt water nor the sea spray. Hence to prevent encroachment on the land by the sea and by blowing sand, the Sea Lyme is planted on those sands within reach of the sea, and the Sea Mat on those farther back. Nature at times uses this arrangement, but at times man has to intervene and plant these sand-binders for his own advantage.



Sea Lyme Grass (*Elymus arenarius*)

The stem is 3 or 4 ft. high, and the eared leaf-blade often 2 ft. long, inclining to roll up. At

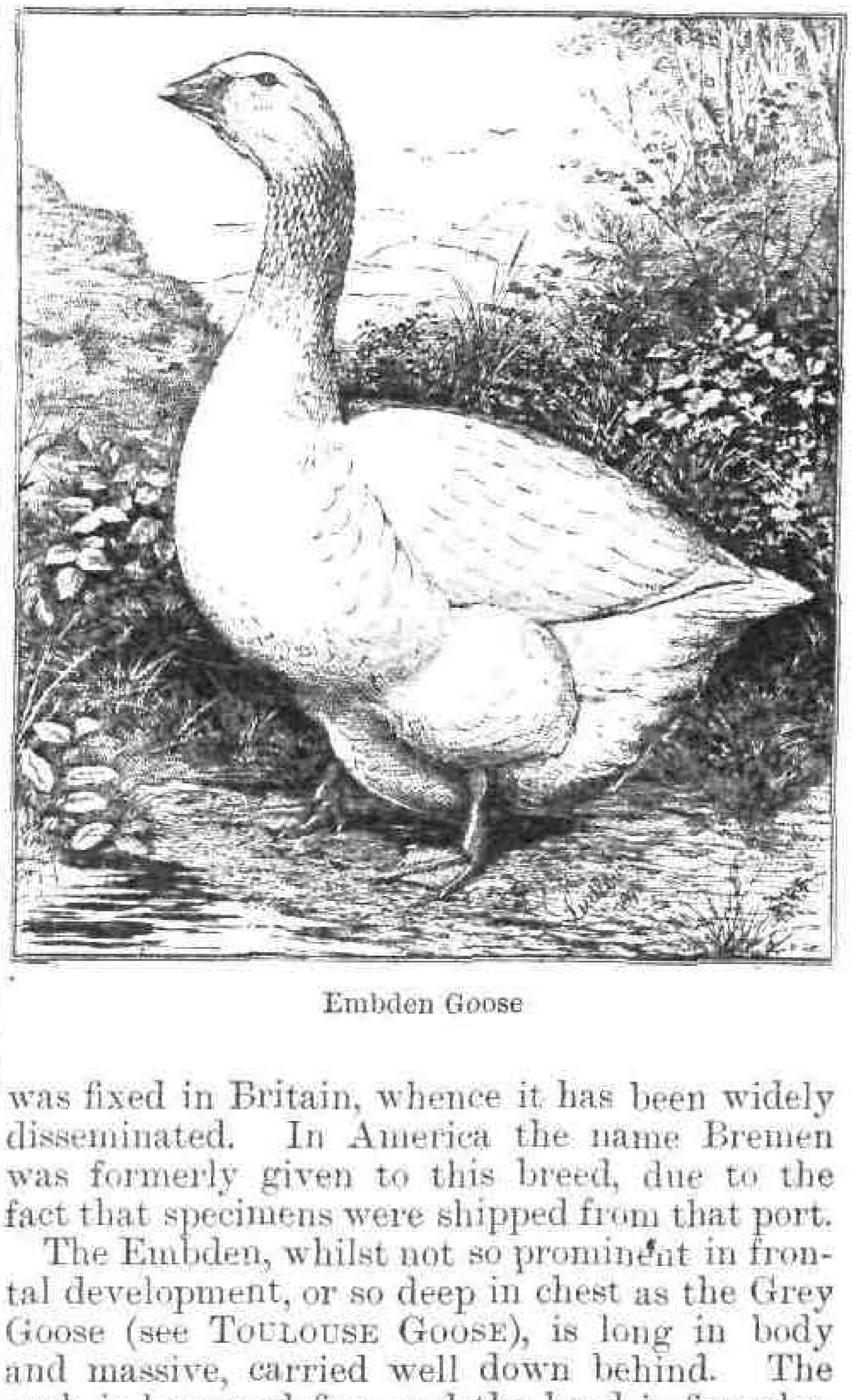
the end of the stem is the down-covered ear, not unlike that of Rye: it takes the form of a two-rowed spike, and is not cylindrical like the ear of Sea Mat Grass. The spikelet is composed of two or three flowers, each enclosed in a pair of beardless (*awnless*) scales (*pales*), the whole surrounded by two barren scales (*glumes*) as long as the rest of the spikelet.

For propagating the plant on sandy shores, cuttings are dibbled into the sand in spring to a depth of 6 or 10 in. The difficulty is to secure that the cuttings are not covered over by the blown sand. This difficulty, of course, is most marked when seeds are used for reproducing the plants. In such a case, turf may be deposited at regular and short intervals, and in the interstices the seeds of the Sea Lyme mixed with clay and dibbled in at the rate of about 20 lb. per acre. The 'sea dykes' of Holland are made of the sand bound together by the Sea Lyme; many instances of the cultivation of this grass may be found on the sandy coasts of Britain, for example at Troon. [A. N. M'A.]

Embankment.—Operations of this kind on estates are limited to the damming back of water for motive power or for ornamental purposes; in some cases perhaps as a source of supply for mansion or homestead. Roadmaking calls for more or less of it too; and at many places the maintenance of the banks or sides of streams involves a considerable annual outlay.

On the estate there is rarely need for the puddle trench, the embankments there dealt with being usually of so rudimentary a nature as not to require this. It is seldom that one has deep water to contend with. This one may have to encounter where the water is to be retained in a restricted space such as a gully. But in an instance of this sort, building can be introduced to buttress the embankment. As a rule it is practicable to spread the water out, and thus make it more easily held back; and in the case of deep water to carry the inner face of the embankment with a very slow gradient towards the water. In this way we can have shallow water up to the base of the retaining bank, thereby relieving the latter of any excessive pressure. The main points requiring attention are to make sure of a good foundation, to start with a broad base, and not to be sparing of material. It must bear on the firm subsoil. Any material containing organic matter left between it and the subsoil would leave a flaw between the two when decomposition set in. This is of less moment in the case of an embankment that is not related to damming purposes. The river bank is more a field for protection than of construction. We have to face erosion, and guard the bank against this either by timber or by pitching—facing with stone. Willow bushes can in many cases be brought to one's aid in this connection. The inner face of the embankment for retaining water is much the better for being pitched or paved with small stones. This at the water line protects the bank against the lap, lap of the water, which has considerable wearing effect. The free side should have a much greater slope than the angle of repose of the stuff made use of necessitates, which, however, we have already inculcated under the head of not to be sparing in the matter of material. [R. H.]

Embden Goose.—How long geese of this type have been known in western Europe it is difficult to state, but white geese are widely distributed all over the Continent, as well as in the British Isles. So far as we can trace, they have been known for hundreds of years in Britain, but formerly they were smaller in size than the Embdens of to-day. In Germany, larger specimens have for long been common, and it has been suggested that the Embden is due to a cross of the German White on the White English. Certain it is that although the name is derived from a town in Hanover the breed



Embden Goose

was fixed in Britain, whence it has been widely disseminated. In America the name Bremen was formerly given to this breed, due to the fact that specimens were shipped from that port.

The Embden, whilst not so prominent in frontal development, or so deep in chest as the Grey Goose (see TOULOUSE GOOSE), is long in body and massive, carried well down behind. The neck is long and fine, and the head is fine also. The wings are powerful, and the legs stout, giving the appearance of fair length and active carriage. The bill and the legs are orange in colour. The plumage is pure-white throughout, and in good specimens clear and bright. This fact is more important than at first sight might appear, as white feathers are always of greater value than the coloured. Well-grown adult ganders will range ftom 25 to 30 lb., and geese 18 to 23 lb., but the tendency now is to breed smaller-sized birds.

Geese are kept principally for reproductive purposes, and though the Embden is not a very good layer this is not a serious failing. They are excellent sitters and mothers, in fact breeders

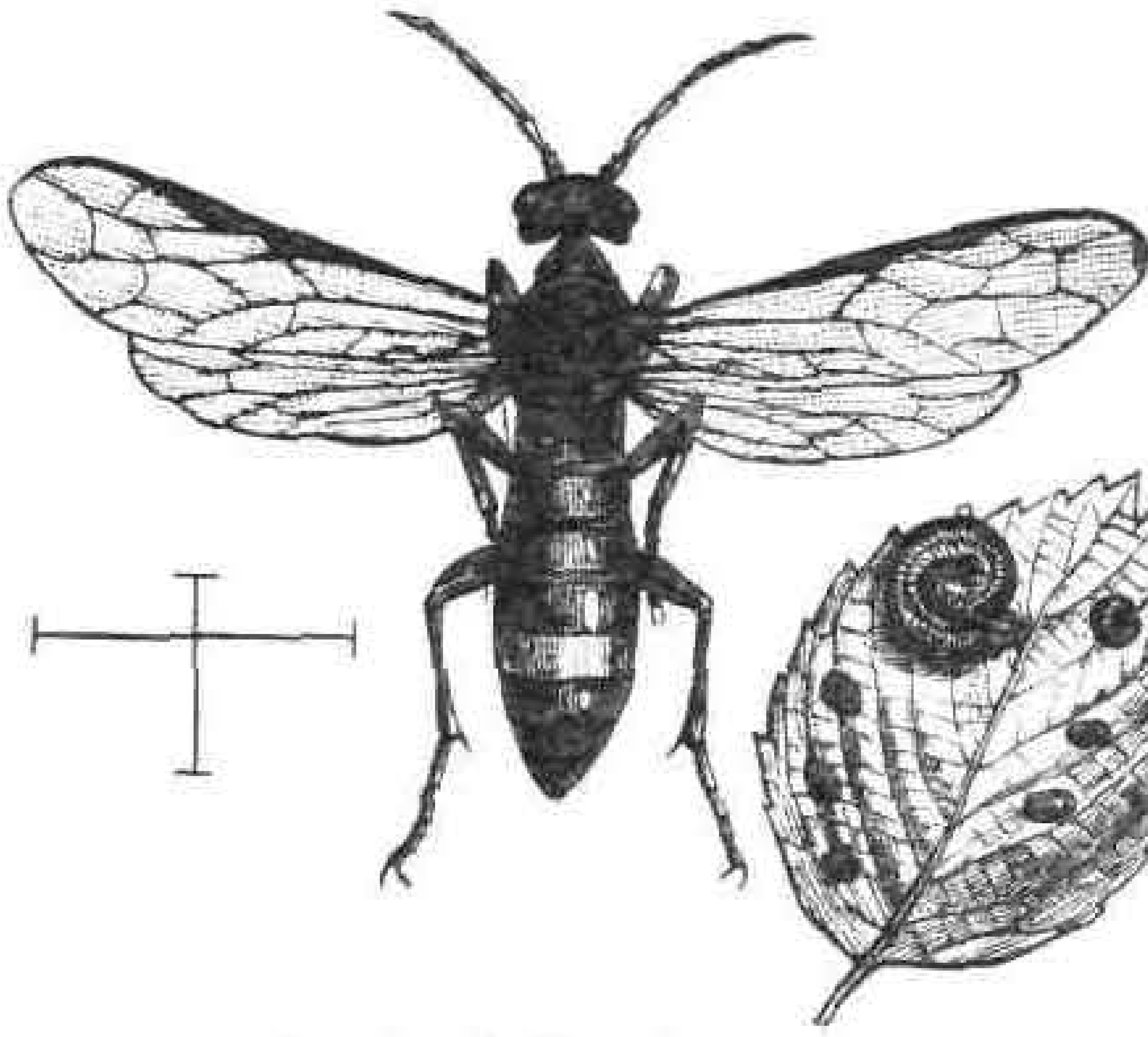
would often prefer them to lay more and sit less. The young birds are quick growers, which is an important point in their favour, for if hatched in April and early May they will attain an excellent size for the Michaelmas markets, when 10 to 14 lb. birds are chiefly in demand. At that time the Toulouse is in very poor condition, as it is slower in growth. For the Christmas trade the Embden geese can be fed to a large size, and as they are fleshy at both seasons it is not surprising that these birds have won a large amount of favour wherever geese are in demand. See GEESE, BREEDING OF. [E. B.]

Embryo, a young organism in the course of its development up to the time when it becomes free from the egg envelopes, or from the fœtal membranes, or from the parent. We call a developing animal an embryo till it is hatched or born, or till it begins to feed for itself. In the case of all but the very lowest mammals, the unborn embryo, still enwrapped in the amnion and allantois, and still organically attached to the uterine wall, is called a *fœtus*, though the term embryo is always applied to the very early stages. When the young creature which is hatched is not like a miniature of the parent, but is markedly different, the term *larva* is used, and the transition from larval to adult form involves a *metamorphosis*. Thus the unborn foal after its earliest stages is a fœtus, the chick within the egg is an embryo, the tadpole of the frog is a larva. It cannot be said, however, that the distinctions between these words are very important, or that they are very rigorously observed. [J. A. T.]

Emmenthaler Cheese.—Emmenthaler cheese is chiefly and most plentifully made in the canton of Berne, being named from the Emmenthal, or valley of the Emme. In other parts of Switzerland they are also made, but to a much smaller extent, often in chalets high up in Alpine summer pastures which, bespangled with beautiful flowers, closely approach the lines of eternal snow. Cheesemaking in such surroundings becomes an idyllic art. Equipments of these Alpine dairies are somewhat primitive and cumbersome, but the process of manufacture is quite elaborate, though not dissimilar in fundamental principles from that of most other varieties of hard cheese. The process followed in Emmenthaler cheesemaking, however, is such that a peculiarly piquant but pleasant flavour is developed, and this accounts for the popularity of the cheese in many countries in all quarters of the globe, to which it is exported. A distinguishing feature of this cheese when cut is the number of circular openings in it, each large enough to hold a small marble. They are pretty equally distributed in the body of the cheese, and sometimes contain a little liquid. In a perfect Emmenthaler, however, this liquid has become absorbed during the ripening of the cheese. [J. P. S.]

Emmer, a two-grained spelt wheat, known under the botanical name of *Triticum sativum dicoccum*. See WHEAT.

Emphytus cinctus (the Rose Emphytus).—The larvæ of this sawfly feed on roses, eating the leaves along the edges, and when at rest they curl themselves up in a ball on the under side of the leaves. They are found from July to October. Their body is stout, cylindrical, thickened towards the fore part; head brownish or yellow, with a broad black band from the back of the head to the middle; the upper part of the body is dark-green, the sides greyish-white; the skin wrinkled and beset with small shiny-white tubercles. Legs white, with a blackish-grey mark over each of them. They pupate in the rose branches. The female sawfly has a black thorax with two white spots; abdomen black, the fifth segment with an incomplete white band; legs black, base of femora and apex of all the tibiæ white, rest of tibiæ and tarsi reddish; the male has no white abdominal band. Length rather more than ⅓ in. They may be found in most gardens, and lay their



Rose Sawfly (*Emphytus cinctus*)

eggs on the under side of the leaves, usually several together. *Treatment* consists of spraying with lead arsenate and pruning off the tunnelled shoots, easily seen by their premature decay. [F. V. T.]

Empidæ, a family of dipterous or two-winged flies, which live upon various insects, including *Diplosis tritici*. Many species are abundant in June in cornfields, one of which is *Empis livida*. The female is ⅓ in. long, of an ash colour, with orange-coloured legs and black tarsi; the wings are transparent. They are all furnished with a long horny beak, admirably adapted for holding their prey. [J. C.]

Employers' Liability. See MASTER AND SERVANT; WORKMEN'S COMPENSATION.

Emu.—Emus and cassowaries form a well-marked family of the struthious order of birds, which, setting aside some now extinct species, comprises in addition to them the ostriches of Arabia and Africa, the rheas of South America, and the kiwis of New Zealand. The family to which they belong, the Casuariidæ, may be distinguished from the ostriches and rheas by the more rudimentary state of the wings, which have only one digit instead of two, and by the presence of an accessory after-shaft as long as the main shaft on the feathers. In this last particular they also differ from the kiwis, which are further distinguished from all existing stru-

thious birds by having a long slender bill with terminal nostrils, and a distinct first toe or hallux on the feet. Emus, belonging to the genus Dromæus, differ principally from cassowaries (Casuarius) in having no helmet on the head, and in having the claw of the inner toe short and like those of the two remaining digits. Although one species of cassowary occurs in Northern Australia, the Emu must be regarded as the typical representative of the ostrich tribe of that continental island. It was formerly very abundant wherever open grassy plains or sandy tracts overgrown with bushes and scrub afforded conditions suitable for its existence; but it has now been exterminated over large areas of the country, and is nowhere plentiful unless it be in outlying districts remote from the habitations of civilized man. The chief cause of its growing scarcity is the excellent sport it affords owing to its great fleetness of foot. It is chased on horseback with dogs, and even when run down makes a bold fight for life, kicking over its assailants with well-directed outward and backward strokes of its feet. It is stated to feed principally upon grass and herbage of various kinds; but it is probable that insects, lizards, and other small animals form an important part of its diet; for in captivity these birds have been found to do well if fed upon chopped meat and bone as well as upon green food, broken biscuit, and boiled maize and rice. The bird is hardy, and has been successfully introduced into Europe and North America, and lives well both in large parks and in the smaller enclosures in zoological gardens. Under favourable conditions it breeds readily in captivity, the chief difficulty to the rearing of the young birds being apparently the difference between the seasons of Australia and the northern hemisphere, the spring of the former country, when the birds naturally breed, corresponding with the autumn in Europe. The nest is hardly more than a shallow depression in the ground; and the eggs, which are deep-green in colour, about 5 in. long, and vary in number from about six to twelve or more, are incubated solely by the cock bird, who also assumes the entire care of the brood after hatching. The period of incubation lasts about sixty days, and the chicks are covered with down and ornamented with alternate stripes of brownish-black and greyish-white extending longitudinally from the head down the neck and back. The cock is seasonally monogamous. Unlike the ostriches the sexes are not distinguishable by colour, and there is no great disparity in size. The voices of the two, however, during the breeding season are different, that of the cock being a guttural grunting growl, while that of the hen is a muffled booming like a cavalry drum.

There is only one species of Emu (*Dromæus Novæ-Hollandiæ*) known at the present time, the so-called Spotted Emu (*D. irroratus*) believed to replace the common form in Western Australia having been based upon immature specimens in which the plumage is more speckled than in the adult. A distinct local race formerly occurred in Tasmania, but has been exterminated; and a similar fate has overtaken a dwarfed black Emu (*D. ater*) which not long since existed in Kangaroo Island, off the coast of South Australia. [R. I. P.]

Endemic Diseases.—This term is applied to a class of maladies that are commonly prevalent within a limited area or particular locality, as opposed to those diseases that occur from time to time and spread over a larger area, being known as 'epidemic' It will be readily understood that an endemic may through following the lines of traffic, or through multifarious agencies, be transformed into an epidemic, but there can be no conversion of the last named into the former. In the case of animals, an endemic disease is more strictly designated an 'epizootic' disease. Almost all agriculturists are familiar with a common disease affecting sheep, known as liver rot, the presence of which disease in particular localities—chiefly those of a marshy nature (exclusive of salt-marshes)—is a well-known fact. Influenza in the horse, though universal in its distribution, usually assumes *endemical* characters. Abortion (specific) affords a typical example of an endemical disease, and the reason of this is that it is confined to one sex, and chiefly amongst cattle. Yellow fever in the human subject is endemic in certain parts of America, the West Indies, &c., but it also assumes epidemical characters in dirty seaport towns in tropical countries, the infection being carried by ships to the ports. Many parasitic (worms) infestations assume true endemic characters, *e.g.* Lincolnshire lamb disease. In a recent outbreak of foot-and-mouth disease in Scotland the malady remained confined to the stock belonging to one owner, and this because of the stringency of legislative measures, otherwise there is every reason to believe that the complaint would, with lightning rapidity, have assumed epidemical characters. [F. T. B.]

Endive (*Cichorum Endivia*), a hardy annual related to the Chicory. It has long been cultivated for its leaves, which are used for salads

Endive—Broad-leaved Batavian

in the same way as lettuce leaves are. It requires less warmth than the lettuce, and is therefore most useful for a late autumn and winter supply. The seeds should be sown thinly towards the end of June, a second sowing being made a month later, and a third in mid-August. The sowing and treatment generally should be exactly as for lettuce. When the plants are nearly full grown the leaves should be bunched together and tied near the top, an

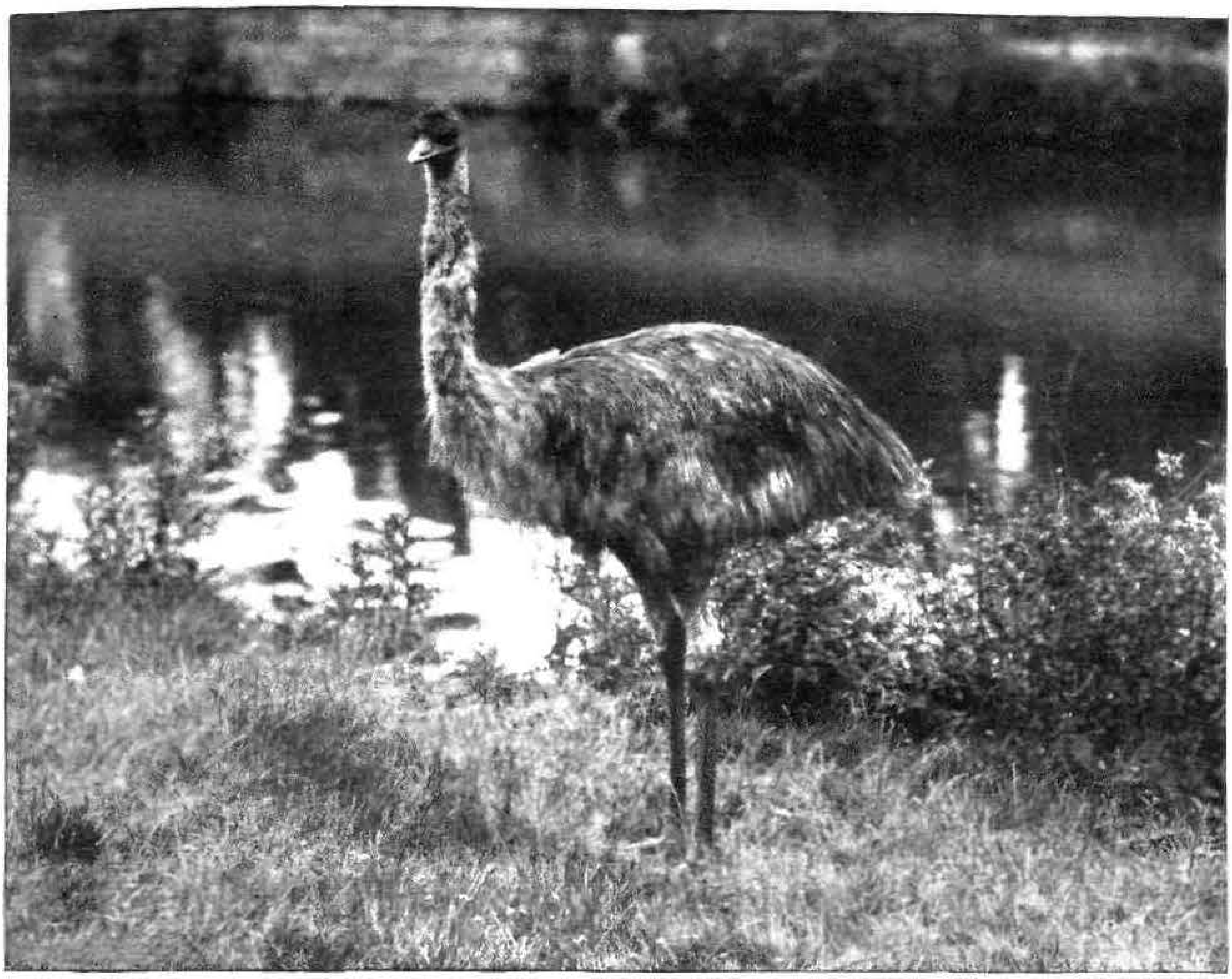


Photo. Chas. Reid

EMU

Photo. Chas. Reid

FALLOW DEER

inverted flowerpot being placed over the whole plant; or if the rosettes are spreading and flat they need not be tied, blanching being effected by laying a slate or flat tile on the top of each, while if the plants are in rows boards may be used, two for each row, placing them so that they form a span roof over the plants. A thick mat serves the same purpose. By thus keeping them in the dark the younger leaves remain tender and more or less blanched, and their flavour is also less bitter. The best varieties are the Batavian, Incomparable, Large Green Curled, Small Green Curled, and Exquisite Curled. [W. W.]

Energy.—The term 'energy' as applied to a body, or to a material system, is used to denote the power or capability of doing work which the body or system possesses.

As commonly applied, though not always correctly, to a portion of matter, the energy which a body is said to possess may be due to its position, to its condition, to its intrinsic properties, or to its motion. For example: a raised weight is said to possess energy in virtue of its position; for if it were allowed to descend under the action of gravity it could, during its descent, raise another weight, or drive a pile, or do some other work. As, however, the force of attraction between the body and the earth is mutual, and as it is this force, acting through a distance, which does the work, it is more correct to say that the energy manifested is due to the separation of the one body from the other. Again, a coiled spring evidently possesses energy in virtue of its condition, as it can be used, for instance, for driving the mechanism of a clock; and a mass of gunpowder possesses energy in virtue of the unstable equilibrium of the chemical forces affecting its molecules, or, more generally, in virtue of the chemical separation of those elements, which, on combining together, produce a manifestation of energy.

POTENTIAL AND KINETIC ENERGY.—The energy referred to in each of the above examples is of the kind known as *potential* energy, in contradistinction to energy of motion, or *kinetic* energy as it is called. As an example of the latter, let us consider the case of a cannon ball projected vertically upwards with a velocity V, say. If there were no air resistance, it is known from experiment that its upward velocity would diminish at the rate of about 32·2 ft. per second per second—a rate which is usually represented by the letter g. Hence the ball would come to rest after an interval of time t, where $V = g \cdot t$; and as its mean velocity during the interval is $\frac{V}{2}$, it would rise to a height h, where

$$h = \frac{V}{2} \cdot t = \frac{V}{2} \cdot \frac{V}{g} = \frac{V^2}{2g}.$$

Further, if W be the weight, and m the mass of the cannon ball, the work done in raising it to a height h would be $Wh = \frac{W \cdot V^2}{2g}$, in gravitational units, or $m \cdot g \cdot h = m \cdot g \cdot \frac{V^2}{2g} = \frac{1}{2} m \cdot V^2$, in absolute units; and as the energy of motion has been entirely expended in the process, we conclude that a body of weight W, or mass m, moving with a velocity V, possesses an amount of energy in virtue of its motion which is expressed by the formula—

$$E = \frac{W V^2}{2g} \text{ or } E^1 = \frac{1}{2} m \cdot V^2.$$

The energy which has thus been expended in raising the cannon ball has not been destroyed, however, but simply transformed into energy of position or potential energy; for on descending again it would acquire more and more momentum, and finally (assuming no air resistance) reach the earth with the same velocity as that with which it was projected upwards. We have here, therefore, an example of energy disappearing in one form while doing work, and entirely reappearing in another form; the amount of energy thus transformed, expended, or exerted being exactly equal to the work done.

Heat is another form of energy. In a hot body the molecules are in rapid motion, and the hotter the body the more rapid is the motion. This motion is invisibly small, but the energy which a body possesses in virtue of such motion may, at least in part, be transformed, for instance, into energy of visible motion. For example: the hot fuel in the furnace of a boiler generates radiant heat, which, on being communicated through the furnace walls to the water, overcomes the molecular forces of cohesion of the latter and produces steam. The particles of steam, being in rapid motion, impinge upon one another and upon the walls of the enclosing vessel, thus producing pressure and giving to the steam that property of expansion which, in the cylinder of an engine, produces the visible motion of the piston.

From the above examples it is evident that energy of both the kinetic and potential types is exhibited sometimes as energy of visible masses of matter and sometimes as energy of molecules. The many different forms in which energy is exhibited naturally falls, therefore, into four divisions, viz.:—

1. Energy of motion of sensible masses of matter; *e.g.* wind, flowing water, rotating fly-wheel, &c.

2. Energy of motion of molecules; *e.g.* radiant energy, pressure of a gas, &c.

3. Energy of separation of sensible masses of matter; *e.g.* water above sea level, a magnet and its armature, two bodies charged with opposite kinds of electricity (electrical separation), &c.

4. Energy of chemical separation; *e.g.* carbon and oxygen, which on combining in the burning of ordinary fuels generate heat; food, which on consumption and utilization in the animal system produces vital and muscular energy.

The ultimate source of the energy exhibited in all these forms is readily traceable to the sun. The muscular energy developed by animals is, as we have already stated, derived from the chemical energy of the food which the animal consumes, and this food is always vegetable food actually, or food produced therefrom. Now the growth of vegetation is effected by the energy

radiated from the sun in the form of heat and light, which decomposes carbonic acid in its tissues. Hence animal power is derived ultimately from the sun; and when we use fuel in an engine we utilize energy radiated from the sun to the earth in past ages. Again, it is the heat of the sun which causes evaporation from seas to form rain and waterfalls, and it is this heat which causes the atmospheric currents. The natural powers of water and wind are thus due entirely to the sun, and so also is every form of energy with which we are acquainted.

Now in every pound of wood there is stored as much energy as that developed by a horse in working at its full power for two and a half hours, or about 2200 foot-tons; while a pound of average coal, plus the oxygen necessary for its complete combustion, represents about 12,000,000 foot-pounds of energy, or as much as would keep a 6 horse-power engine going for about an hour if it could be fully utilized in the process, and a pound of petroleum possesses as much energy as three pounds of wood.

Again, the energy available from waterfalls in this country is probably not less than 150,000 horse-power, of which 12,000 horse-power is actually utilized; and the power of the Niagara Falls is greater than the estimated total power of all the steam and gas engines in the world, while that of the Victoria Falls, at certain periods, is ten times as great.

When we further consider that the coal supply in Great Britain alone is probably sufficient to last us 400 years, and that there are many other great stores of energy in the world in the form of wood, coal, petroleum, &c., we begin to realize somewhat how enormous, as compared with, say, the work which can be done by a horse in an hour, are the stores of energy which nature has provided and provides for our use.

TRANSFORMATION OF ENERGY.—When energy is expended in doing work it is not destroyed but simply changed in form, and in this way energy of one form can be transformed, either directly or indirectly and either wholly or in part, into energy of any other form. Thus, during the upward motion of the cannon ball previously referred to, the kinetic energy of the ball is gradually transformed, while doing work, into potential energy; and then, during the descent, this potential energy is expended in accelerating the ball and is thus transformed back again into energy of motion. Again, during the combustion of fuel the energy of chemical separation is transformed into heat, and if this heat be used in an engine driving a dynamo it will be transformed into electrical energy in the form of an electrical current. This energy may then be transformed back again into heat by passing the current through a very thin wire, or the carbon filament of an incandescent lamp; or it may be transformed into energy of chemical separation by passing the current through acidulated water in a voltameter, when the water will be split up into its elements of oxygen and hydrogen. As another example we will take the case of an axle and bearing of a railway wagon. Here energy is expended in overcoming the frictional resistance between the axle and its bearing and is thus transformed into heat, which, producing a rise of temperature, melts the axle grease provided for purposes of lubrication. And in the same way, whenever the molecules of a body are agitated frictional resistances are overcome and heat produced; and for every 778 foot-pounds of work done one Fahrenheit heat unit is produced.

Now, though energy of one form can be transformed into energy of any other form, all forms of energy are not equally transformable. For example: energy of any other form can be readily and wholly transformed into heat, but only a portion of the heat of a hot body can be transformed into another form of energy. If a quantity Q of heat at an absolute temperature T_1 be received by a heat engine working between the temperature limits T_1 and T_2, it is proved in thermodynamics that the greatest possible amount which can be converted into work is $Q \cdot \frac{T_1 - T_2}{T_1}$. The heat which a body possesses, therefore, is of no practical value unless the body is at a higher temperature than that of the surrounding bodies, for the lower limit, T_2, of temperature at which a heat engine works cannot be less than that of the surrounding bodies. When energy of any other kind is transformed into heat it assumes a less useful form, and is said, therefore, to be *degraded*. Now, as it is impossible to do work without agitating molecules of matter, during every transformation of energy from one form to another some heat must be produced, and as one body cannot remain at a higher temperature than the surrounding bodies, it would appear that eventually all energy must assume this degraded form, and all matter the same temperature.

CONSERVATION OF ENERGY.—The principle of the conservation of energy asserts that it is impossible by any natural agency to create or destroy energy; or, in other words, that when energy disappears from one form it reappears entirely in some other form, and conversely. This principle simply embodies, in a generalized form, the unvarying result, without exception, of the observations and experiments of many people; and though it does not admit of definite proof, the mass of evidence in its favour is so great as to place the truth of the principle practically beyond doubt. According to this principle, therefore, the 'perpetual motion' over which so many inventors have come to grief is an utter impossibility, as work cannot be done without the expenditure of energy. It also shows that if a material system neither receives from nor rejects energy to outside bodies, the total energy of the system remains constant, and also that the energy of the universe cannot change in quantity but only in form. [H. B.]

Engineering, Agricultural. — Agricultural engineering has been one of the great forces in developing modern agriculture. Both on the farm and on the estate, as distinguishing the tenant's and landlord's interest, the evolution of machinery from the simple methods of the blacksmith to the intricate developments of the scientific engineer has brought about a revolution in methods and possibilities unlooked

for a century ago. The British farmer, with a constant supply of manual labour, has up to recent years been slow in taking advantage of mechanics, but the past decade or two has witnessed great changes, and the farmer now fully recognizes that it is only by such help that he can compete with others who have depended more on machinery, because he has never experienced the position of having unlimited cheap labour. It is safe to say that few industries call for so wide an application of physical principles as farming, because farming embraces so many sections demanding special treatment. A large farmer by necessity must understand many mechanical principles, or he cannot form an accurate opinion of the value of machines he requires to buy; and if he buys them, does not get the full value out of them. It is easier for a farmer to get good and reliable veterinary advice for his animals than to be well advised in respect to his machinery. It is in the interests of the agent who has a machine to sell, to represent it as the best of its kind, to point out its better features, and allow the buyer to find out its weaknesses. When a machine combines intricate mechanical devices, and has to deal with substances possessing physical properties which are not obvious to those who are without some training in physical sciences, it is very easy for them to be misled. The machinery equipment of a farm has such an important bearing on its successful management that there is scarcely any branch of knowledge that is more useful to the farmer than that comprised in the application of mechanical and physical principles. Even in quite simple matters great loss is often experienced, and machines are cast aside because some trifling adjustment is out of order. We have on several occasions seen cases where friction bands which had become loose or had worn smooth so as to lose their grip, oiled to correct them; and neither the farmer nor the man working the machine realized the cause of the failure, with the result that the machine was cast aside while it was practically in as fit condition to work as when new. If many of the common implements which have been on a farm some years are examined, it will be seen that only a few of the adjusting parts have been altered, the nuts remain with the paint undisturbed; meanwhile the implement has not done its work with the ease and thoroughness which it was devised to perform; and all because the simple mechanical principles involved have not been understood. Even in so simple an implement as the plough this may often be seen; the adjustments might just as well have never been provided. When a man is seen struggling with a plough it is generally because it is not set properly, and if not, the plough ought not to have been bought; if this struggling occurs, it inevitably means that the ploughman is applying great pressure to the handles, and therefore the friction on the sole of the plough is greatly increased, and the draught is correspondingly greater. If it were realized how much the draught is increased by friction, ploughs would be set much better; the adjustments are there on all good ploughs. When so familiar and simple an implement as the plough can be so abused, it is not difficult to realize how great must be the loss when more complex machinery is being worked. Probably few but those who buy secondhand steam engines to repair and sell again know how much the engines are injured by ignorant handling, or how often they are cast aside because some comparatively simple and relatively inexpensive part has been allowed to wear and get out of order, having been run until fuel consumption has become so abnormal that the engine has been regarded as worn out. Comparatively few farmers possessing a steam engine are acquainted with the course of the steam from the boiler to the exhaust, or of thermodynamics generally, or can understand the meaning of indicator diagrams; yet they place the engine in charge of a man who knows less than themselves, and whom they cannot correct. The physical properties of milk are but vaguely understood by many dairy farmers, with the result that the full efficiency of the machinery they employ is not obtained, not merely because they do not understand the principles of the machinery, but because they do not realize what is aimed at. Some years ago it was strongly advocated that moist hay stacks should be dried and prevented from overheating by extracting the moisture by means of exhaust fans. The idea seemed so feasible that a large number of engineers made machinery for the purpose. A trial of the machines was made at the Reading show of the Royal Agricultural Society of England in 1882, with the result, which some had prognosticated, that the stacks and plant were burned and the uselessness of the practice was clearly shown. The fact that drawing in more air would supply more oxygen, and thus fan the fire, had been commonly overlooked. A year or two subsequently, when the advantages of ensilage were being put before farmers, the experience with exhaust fans frightened many from attempting to ensile their crops. They did not recognize that the essential principle of ensilage was to keep out air, and therefore keep down fermentation and consequently temperature. The value of agricultural engineering is recognized in agricultural colleges, and there can be no doubt that this is having a good influence on agricultural methods. [W. J. M.]

Engines. See STEAM, GAS, and OIL, WIND, and HOT-AIR ENGINES.

England, Agriculture of.

INTRODUCTORY AND HISTORICAL.—In order to understand English farming in all its modifications, it is necessary to enquire into its gradual development during the more recent centuries. It is not proposed to discuss the farming of mediæval times, or even to describe the agriculture of the 14th century, so ably handled by Professor Rogers. According to Froude, the arable land of England was in an exhausted condition about the middle of the 15th century, and the average yield of wheat was about 8 bus. per acre from 2 bus. of seed, while the rent was from 2*d*. to 4*d*. per acre. An acre of hillside land, with a sprinkling of gorse or furze for fuel, was worth 2, and an acre of meadow was worth 8 ac. of arable land, and the entire

population of England and Wales was estimated by Hallam at 4,400,000 persons in 1588, the memorable year of the Spanish Armada. Even in 1650 it had only increased to 5,450,000, in 1750 to 6,400,000, and at the taking of the first census in 1801 to 8,892,536. Clover was introduced in 1655, and ten years later it was being cultivated as a field crop. Turnips in 1562 were boiled with butter, and used solely as human food; in 1645 they were being given either cooked or raw to the pigs; in 1684 they had been adopted as a field crop for winter sheep food, and by the end of the century their cultivation is described by Lisle (Hampshire) as a matter of course. Our present social system of peers, country gentlemen, farmers, and labourers was developed during the 14th century, at which period villanage was gradually dying out.

The price of wheat fluctuated enormously, and while plenty ruled in one county, the next might be suffering from famine. In 1499 it was 4*s.* per qr., and in 1521 20*s.* During the 'fifties of that century it kept pretty steady at 8*s.* In 1574 it leaped up to £2, 16*s.* In 1594 it was again at famine price, and in 1597 it reached £5, 4*s.*, and kept high till the end of the century (Adam Smith). In the later Stuart period, one-third of England was a barren waste. Gregory King, the Lancaster Herald, during this desolate period computed the area of arable land at 9,000,000 ac., averaging a rent of 5*s.* 6*d.*; pastures and meadows averaged 8*s.* 8*d.*; woods and coppices 5*s.*, and forests and parks at 3*s.* 6*d.* King estimated the price of wheat at 28*s.* per qr., and Professor Rogers at 40*s.*, both of which estimates were no doubt true according to the year in which they were taken (Garnier's History of the English Landed Interest). Garnier further writes that after the early part of the 17th century there could have been no radical change in the English system of farming, unless we except the gradual absorption of the common tillage field into fenced and private enclosures. 'In parts of England, especially in Lancashire, the farming of the latter end of this century (17th) would have been scarcely distinguishable from that practised in the same locality now.' There could scarcely be any signs of what we call high farming, as, according to our authority, things have remained much as they were during the later years of the Stuarts. The personal tradition of the author agrees with the idea of a general continuity of management. It extends back at least to 1750, when his great-grandfather farmed the same acres which he himself occupied in 1864, and apparently managed them on fairly similar principles. There were grass land and arable land; bare fallows, wheat, and beans, with some oats; and so it had been a hundred years before.

The great movement towards a more modern system of farming was inaugurated by the extended use of roots and clover, and the adoption of the Norfolk four-course, in place of the old three-course of fallow, wheat, beans. Turnip husbandry encouraged live stock, and prepared the way for Bakewell, the Culleys, the Collings, the Ellmans, and a host of other eminent breeders. Agricultural improvement was stimulated by high prices, and bone manures came into general use. Liming, chalking, marling, and drainage were held in high estimation at the beginning of the 19th century, and, as it grew older, agriculturists began to turn to chemistry and engineering science for further assistance.

By the middle of the 19th century agriculture had achieved its highest point of prosperity. There was a general movement in favour of breaking up pastures, heaths, and downs; rents rose, and farming became a favourite pursuit with the wealthy. Gilded youth went in hundreds 'to learn farming', and helped to increase the demand for farms. Mr. J. J. Mechi startled the world with his intensive system of farming at Tiptree Hall, in Essex; Mr. (afterwards Sir) J. B. Lawes began his world-known experiments at Rothamsted. Every county boasted leading agriculturists, the contemporaries of James Hope of Fenton Barns, John Wilson of Edington Mains, M'Lagan of Pumpherston, Robertson of Ladykirk, M'Combie of Tillyfour, Grey of Dilston, Outhwaite of Bainess, Hudson of Castleacre, Jonas Webb of Babraham, Samuel Jonas of Chrisall Grange, Harry Overman of Norfolk, the Hewers, Garnes, Strattons, Davys, Quartleys, Mansells, Druces, &c. &c. The galaxy of agricultural talent which shone during the middle portions of the 19th century has never been rivalled. They rejoiced in improvement, and were encouraged by good prices. And yet this superstructure was destined to receive a shake which wellnigh ruined it. If 1879 is remembered as a disastrous season, it also seems set like a pillar of cloud between the prosperity which preceded and the adversity which followed it. The 'eighties and 'nineties saw the great fall of wheat prices, which culminated in 1894 in the miserable price of 17*s.* per qr.! Nothing could stand against this, and land speedily was laid away, or fell away, into grass, and English agriculture was freely stated to be ruined.

Relief was certain to come in time, for the fall in wheat and cereals, in beef, mutton, wool, cheese, milk, potatoes, and every kind of produce, induced a fall in rents, feedingstuffs, manures, implements, store stock, and seed; while labour was reduced, not by lowering wages, but by employing fewer hands, and the adoption of labour-saving machinery. Thus the balance was gradually restored, and middle-aged farmers now scarcely remember the revolution of the 'eighties, nor the grand agriculture of the 'sixties.

As to the subject before us, many of the best examples of modern farming lie behind us, buried in the annals of agricultural journals. They differ from extant cases in this important respect, that in the earlier time they were carried out upon ordinary rotations of crops and with ordinary stock. It was the aim at that time to produce 60 bus. of wheat and barley, 100 bus. of oats per acre, together with beef and mutton, wool, roots, or potatoes. In Norfolk such men as Leeds, Overman, and Hudson consumed, as the writer knows, over £3000 worth of cake a year. Their crops were wonderful to see. It seems unfair to single out Norfolk particularly, for the

same high farming prevailed in every county. There was little choice, although there were backward districts and counties, relieved by bright examples. If, however, we take Shropshire as a type of the west Midlands; Oxford, Bucks, and Northampton of the east Midlands; Wilts and Dorset of the south-west; Kent and Essex of the south-east; and Bedford, Cambridge, Nottingham, and East Yorkshire of the east, it is difficult to say how far one excelled another.

LANDLORD AND TENANT.—In considering the farming of England it is necessary to glance in the first place at the three estates which constitute the landed system of the country, namely the landlords, tenants, and labourers. It has already been stated that the original feudal system gradually changed during the 14th century into the more modern divisions of peers, country gentlemen, farmers, and free labourers.

The farming systems of England are very different from those of the Continent. In France the land is cut up into peasant properties intermixed with large estates. In Germany and Austria-Hungary, peasant properties are interspersed among enormous estates (Herrschaften) managed from a central bureau, often situated in Vienna. Russian rural economy is, or was, simple serfdom; and if we take Europe throughout, there is little parallel with our system of independent tenants, who are the backbone of English agriculture. The relations between landlords and tenants are, as a rule, of a cordial nature, the result of mutual esteem, and in many cases of mutual affection. The tenant freely accords due respect to his superior, while the landlord regards his tenant in some degree as a dependant, on traditional grounds, but in many cases as his social equal and friend. Tenantry involves no inferiority, but implies loyalty and support. The landlord is not only the owner of the land, but he is the natural heir of all the improvements which have been made by his predecessors and past tenants. These latter, he may have acquired by purchase; for all claims for unexhausted improvements must ultimately be defrayed by the landlord; or they may have fallen in to him legally at the termination of tenancies, without payment. In either case the landlord stands possessed of the holding with all its equipments of buildings, fences, and roads, and of its accumulated fertility. He is in a position to treat with a new tenant after discharging his liabilities to the old one, unless, as in most cases, he allows the incoming tenant to treat directly with the outgoer. If he resumes possession, he must pay; but if he lets the farm his debt still remains as a perpetual liability.

The landlord therefore may be regarded as the 'maker of the land' so far as it is removed from prairie value; and the work of the landlords (conjointly, it is true, with the tenants) is represented by the present condition of the land. No doubt in times past there have been rapacious landlords who have resumed possession without compensating their tenants. They must, however, have acted legally, as there appears to have been no means of redress. Happily this evil state of affairs has been remedied by various Agricultural Holdings Acts, and the tendency of modern legislation is to confirm tenants in their rights, and even to secure them in quiet possession. There is, however, no dual ownership in England as there is in Ireland. There is no 'goodwill' to pay to the quitting tenant for disturbance, although 'emblements' in the form of tillages, compensation for unexhausted manures, and tenant's fixtures are subject to valuation. As previously stated, these would fall on the landlord the moment he resolved to fill the place of the way-goer himself; or he could discharge this liability, and allow the new tenant to enter free of them. This was often done in Essex when the county suffered from acute depression, simply because no one would take the land on any other condition.

The landlord therefore stands 'seized' of the land and all the appurtenances thereof; and this being the case, we are in a position to ask what he, with the co-operation of all previous tenants, has accomplished. The late Mr. Albert Pell, of Hazelbeach, Northampton, contributed a very important paper to the Journal of the Royal Agricultural Society in 1887, entitled 'The Making of the Land in England', in which, speaking of the present value of land, he first disposes of the fallacy that the landlord is a usurper. He shows the extremely small value of unequipped land; and it has before been shown that, even in the 14th century, when ownership had been confirmed for many centuries, the rent of arable land was only 2*d.* to 4*d.* per acre, and its yield was estimated at 1 qr. of wheat per acre. Writing upon this point, Mr. Pell expressed himself as follows: 'The case of the landowner and agriculturist is, that in purely rural districts this modern value can be directly traced to the expenditure, for years, of energy and money on the subject-matter itself *by its owners*, the capital sum of which, when taken into account, may possibly be found to exceed the market value of the estates on which it has been expended'. Mr. Pell gave numerous examples of the truth of this statement. He showed that when the buildings, houses, roads, fences, drainage, and all other equipments of a farm are valued, the amount expended is very much above its market value. Also that there are other incidentals which are a part and parcel of land-ownership and its duties, such as the building of churches and schools, provision and maintenance of burial grounds, and subscriptions for the alleviation of poverty and suffering, which the landlord is morally bound to assist.

In reviewing English agriculture the landlord must therefore occupy an honoured place, and no apology is necessary for according him the premier position in the rural economy of the country.

MAIN FEATURES OF ENGLISH FARMING.—We now turn to the main object of this article, namely, a review of the farming of England. It has achieved an eminent position and high reputation throughout the world. Continental works on agriculture constantly refer to English practice, and in fact they present agriculture through English spectacles. Our breeds of live stock are described and highly commended,

and this is endorsed by the purchase of English horses, cattle, sheep, pigs, and poultry, by foreign buyers every year. No doubt the agriculture of other countries excels ours in many points, as for example in the cultivation of the vine and tobacco, as well as many other products. English agriculture is simpler than continental and tropical agriculture. Our crops are much fewer in number and simpler in their cultivation. We do not produce oil, wine, sugar, tobacco, maize, and many other crops requiring special cultivation, but it is all due to climatic disabilities. English agriculture looks poor when we contrast our wheat, barley, oats, beans, peas, potatoes, roots, and hops with the long list of continental crops. Again, when we summarize these crops, as corn, pulse, roots, potatoes, and grass, the list seems short, and the cultivation involves a few simple operations, such as ploughing, harrowing, drilling, and rolling. It sometimes appears as though there was little to be said which could not be said briefly about our crop cultivation; for English agriculturists part with their products as raw materials, straight from the land. They seldom deal with any phase of manufacture, for the days are gone when wool and flax were spun, when beer was home-brewed, bacon home-cured, and beef salted down. Even butter- and cheese-making have fallen into comparative disuse, and the English farmer washes his hands of his produce as soon as he can market it in the raw state. In this respect English agriculture differs from continental, for there each peasant makes his wine, and is expert in home industries, which, we regret to see, have disappeared in this country. English farming, at its best, is a pursuit of capitalists. A farmer of over 500 acres seldom soils his hands with manual toil, and his wife and daughters have ceased to live the simple peasant life. They no longer make butter and cheese, for the raw milk goes daily to the factory or the railway station. They no longer cook for harvestmen, for the self-binder has supplanted that. They do not even draw beer for the haymakers, much less go out to sweeten the hay with their presence; for beer is not now given, and the hay-tedder and horse-rake have banished the fork and the old hay-rake for ever. Farmers are gentlemen, and their wives and daughters are ladies, for the occupation is agreeable and free, and no longer makes demands upon the household.

One of the best accounts of English farming was written by M. Léonce de Lavergne before 1855, and translated by a Scottish farmer in that year. Though drawn up so long ago it has the merit of having been written before the collapse of wheat prices took place, which has been already referred to. What M. Lavergne wrote in 1855 is substantially true to-day. 'The farmers of England enjoy a revenue at least equal to our French proprietors. The farmer of 250 acres, for example, has an income of £120, while a proprietor with us of a like extent, and under average circumstances, would realize no more. Farmers in the best parts of England make 15*s.* to 30*s.* per acre, and there are some whose incomes amount to from £500 to £1000 a year. Hence the importance from a social point of view of that class, which is as firmly rooted upon the soil as property itself. These are the gentleman farmers; they live for the most part in a quiet, comfortable style, have their newspapers and periodicals, and produce upon their table a bottle of claret or port. One meets with a hospitable reception from these kind and simple families, many of whom have occupied the same land for several generations. Comfort has gradually been built up by the industry of successive generations, and they enjoy it as an honourable and laboriously acquired possession. None of them ever dream of becoming proprietors, *for they are better off as they are*: to have £100 a year as a proprietor, a capital of at least £3000 is necessary, whilst £1000 is sufficient to produce the same income as a farmer.' Again, speaking of Norfolk, he wrote: 'The farmers, who are mostly wealthy, live in a liberal style. Some of them have fine houses, numerous servants, and keep their hunters and superb harness horses.' He might have added, breed pheasants and enjoy their sport like country gentlemen. English agriculture has passed through many vicissitudes since M. Lavergne wrote his masterly work, but the farmer has maintained his position, and it is probable that he has increased his profits above the amount just recorded. He has gravitated more and more towards live stock, and those who have been successful have in many cases amassed large fortunes. They are more decidedly business men than their predecessors in the 'fifties, and are frequently called from home in their own interests, or those of various societies.

THE LABOURER.—The agricultural labourer has participated in the cheapness of food and clothing due to free trade, while at the same time his wages have doubled. The rural exodus of which we hear so much, is due to the great extent of land laid down to grass, and also to the introduction of machinery. Those remaining, receive good wages, and earn about £1 a week during the spring, summer, and autumn. The winter wages are lower, and vary from 12*s.* to 15*s.* a week according to locality. In many cases they live in rent-free cottages, their hours are not long, and their labour is not, as a rule, arduous nor disagreeable. In many respects the position of the labourer is better than that of either the landlord or the farmer, for his wants are supplied, and his wages are regularly paid. The tendency in respect of education, sanitation, and relief in times of necessity are all in his favour, and his position is enviable in comparison with that of town labourers. The author is an admirer of the English agricultural labourer. He is well skilled in his work, fears no weather, and is a faithful servant, endeavouring to do a fair day's work for a fair day's wage. Those who have to do with live stock are experts of no mean order, as is exemplified by the confidence reposed in them by their masters. Looking at them in their several capacities as foremen, teamsmen, shepherds, cattle- or dairymen, barnmen, enginemen, thatchers, mowers, harvestmen, &c., they well deserve their wages. They are gifted with a large stock of sound

knowledge, and the older and experienced men are always worth talking to on the subject of their work.

Corn Growing.—The English climate is favourable in a special degree to the growth of grass and roots, but is not so well adapted for wheat as drier and warmer countries. It is suitable for barley and oats, and in regard to this last crop it thrives better in the northern and less hospitable parts of the country than in the south. As a wheat-producing country, England occupies a somewhat exceptional position. It is seldom that the season entirely suits this crop, and it is noticeable that in the special reports annually published by The Times the last bumper crop, which was estimated at the exceptional figure of 103 (100 being a full crop), was produced in 1898. There was another good crop in 1905, but since then the averages have been lower each season, until they arrived at 87·7 in 1908. The English summer is not hot and bright enough for wheat, and yet the average yield was 31·18 bus. per acre for the ten years 1896–1905. Contrasted with the 8 to 10 bus. per acre produced in several of the United States of America, and the 12 to 15 bus. produced in France, this is an extraordinary result, due to the following causes. First, the less frequent growth of wheat in England, the crop not being taken more than once in four years. Next, to the fact that it is only sown on land at its best, that is after roots or clover. Third, that the farming of England is more intensive than in most countries. The yield of wheat in the 14th and 15th centuries was only 8 bus. per acre, or much the same as Nebraska and the central United States, and the increase up to the present high level is due to cultivation, and the accumulative effects of farmyard manure. England was always a wheat-growing country, and was known in ancient times as 'the granary of Rome'. The quality of the grain is excellent, being rich in starch, if rather poor in gluten; but the large yield per acre overrides any deficiency in quality compared with the produce of Canada and the States. The same conditions which render English wheats soft and starchy, operate beneficially upon barley, for the best malting samples are those that are rich in starch and poor in nitrogen (see Barley). The English climate is in fact unrivalled for barley in all the eastern and southern parts of the kingdom. Oats now occupy the first position in point of extent, and this is due to their greater yield, and comparatively higher value per acre. The area under corn has diminished from 7,785,033 ac. in 1869 to 5,467,082 ac. in 1906; while in the same period the area under wheat has sunk from 3,417,054 ac. to 1,661,147 ac. There has been a large increase in oats, but the principal feature, especially during the last thirty years, has been an increase of 4,000,000 ac. of permanent pasture. Even in one year (1905-6) the increase in permanent pasture in England was 44,240 ac.

Live Stock.—The most important feature of English agriculture is unquestionably live stock. The climate, however unsuitable it may be for exotic vegetation, is admirably adapted for men and animals. It is singularly uniform, being neither unduly hot in summer nor too severe in winter. For outdoor life and occupation it is admirable, and scarcely surpassable. It is humid, cool, breezy, and fairly bracing during most of the year; while the heat of summer is relieved by thunder rains, and occasional spells of wet weather. The consequences are a healthy and vigorous population, so far as humanity is concerned, and an extraordinary quality in all descriptions of live stock. This superiority, although in a great manner due to climate, has existed from remote times: for the Venerable Bede, writing during the first half of the 8th century, stated that 'Britain excels for grain and trees, and is well adapted for feeding cattle'. This is in a measure accidental, for Great Britain possesses nineteen distinct breeds of cattle and about twenty-five breeds of sheep, all of which are excellent. Some of these are original, while others have been evolved by careful selection or as the result of crossing. Something must be ascribed to the natural love of the Anglo-Saxon for country life and for animals, and the remainder to the productiveness of the soil, and the salubrity of the climate for fodder crops. The improvement of live stock has been the principal and most lucrative branch of agriculture ever since the days of Bakewell and Ellman —during the latter half of the 18th century. It is illustrated by the Shorthorn, Hereford, Devon cattle, the Leicester, Southdown, and Lincoln sheep, and these are mentioned not on account of their superior excellence in comparison with other breeds, but because of their having been earliest in the field. It is needless to enlarge upon the transcendent qualities of English horses, the result of importations, crossing, careful breeding, and competition on the racecourse, in the hunting field, and the showyard. The superiority of the English races of swine is equally marked, and the same rule applies to poultry. Even the dogs have long been famous, and are sought after throughout the world; and English bulldogs, sheepdogs, mastiffs, terriers, foxhounds and other descriptions of sporting dogs, are unrivalled in beauty and intelligence.

Milk Production.—English farming is bound up in its live stock, and hence the willingness with which arable land has been converted into pasture. We cannot afford space for enlarging upon this subject, or upon the rise and progress of English live stock. Each breed, with its history, is described in this work under its own name; but the paramount importance of live stock may be again insisted upon as the principal feature of English agriculture. If we take milk production as a test, we find that wherever there is an exit, or an immediate market, for this product, cow keeping has become the order of the day. From Staffordshire, Devon, Dorchester, Kent, Essex, Berks, and all other counties within 150 miles of London, milk is conveyed twice daily in enormous quantities. Similarly, around all our great towns in Yorkshire, Lancashire, Nottingham, and the Midlands, milk is produced and disposed of without the help of the metropolis. The trade is a growing one, and seems to be limitless, as the population keeps pace with the increasing number of cows. The higher esti-

mation in which milk is now held as an article of food is a further incentive, and the regulation of the sheds, buildings, transit, and sanitation of the cows will eventually cause greater confidence in the purity of milk, and tend to its increased use. The new-milk trade is less likely to be interfered with by foreign competition than any other branch of farming. Milk cannot be conveyed over the sea without undergoing a sort of churning process, and without efflux of time. Those farms which can deliver their morning's milk in time for town breakfasts, and their afternoon's milk in time for five-o'clock teas, receive a higher price than is given for more remote supplies, and hence the foreigner is placed at a serious disadvantage. One of the strongest objections on the part of milk producers to the Channel tunnel was that they saw in it a means of depriving them of the only monopoly left to agriculturists.

The production and sale of milk has proved a blow to cheese and butter making, and has to a great extent rendered futile the work of perambulating dairy instructors. It is become universal, and has affected the entire character of English agriculture from Northumberland to Cornwall. Every county contains towns which offer a ready market for the daily necessity of milk; for the population of South Lancashire is known to rival that of London. Milk has displaced beef wherever it can find a market; for a cow in milk extracts more out of her food than does a fattening bullock, and leaves a larger profit. Dry cows cost little to keep, and, in fact, a merely nominal amount; while in forty weeks a cow in milk will yield 600 gal. at 6*d.*, or £15. This is at the rate of 7*s.* 6*d.* per week, while the cost when on grass is not more than 2*s.* 6*d.* or 3*s.* Winter dairying is less profitable, as the cost of feeding is much the same as in the case of fattening bullocks. The milk buyers stipulate that not more than one-half more is to be sent during summer than during winter, in order to equalize the supply and encourage winter milk; but the principal profit is probably made from April to October, when the price is 5*d.* and 6*d.* per imperial gallon.

The total number of cattle in 1870 was given in the Agricultural Returns for that year as 3,757,134, while in 1906 it stood at 5,060,862, of which 2,020,340 were cows and heifers in milk or in calf. Sheep had correspondingly diminished from 18,940,256 to 14,839,927, showing a considerable displacement in favour of cows.

PEDIGREE STOCK.—The breeding of high-class stock is extensively carried on in every county, and the leading farmers are those who have developed either studs of horses, herds of cattle, flocks of ewes, or herds of pigs. The Live Stock Journal, The Stock-breeder, and other journals are the organs of stock-breeders, and the almanacs published each year record progress and give particulars of prices. The Live Stock Journal Almanac for 1908 contains lists of no fewer than 15 horse-breeding societies, 21 devoted to cattle, 25 to sheep, 5 to swine, and 15 to poultry. The exportation of pedigree animals to all parts of the world is an ever-increasing trade. The curious fact that foreign flocks and herds require to be replenished by English-bred sires and dams is alone a great encouragement to English breeders. The high prices given for even ordinary good stores ought to encourage the weaning and rearing of calves; but so absorbed have farmers become in milk production that the calves are disposed of as soon as they are born, either to butchers or for rearing in distant localities. High-class stock is intimately connected with high farming, as is fully explained in the article upon INTENSIVE FARMING, and appears to be essential to its success (see HIGH FARMING).

TENDENCIES OF ENGLISH FARMING.—Having reviewed the position of English farming as regards live stock, we next turn to the essential characters of our husbandry, and in doing so it is necessary to reiterate that live stock lies at its foundation. The original idea which prevailed even sixty years ago, in the period of high corn prices, was, that the home consumption of the produce of the farm was the best guarantee of good farming. Wheat was, of course, an exception, and so also was good barley. The oats, beans, hay, straw, and roots were, however, all consumed upon the premises. 'Muck was the mother of corn', and wheat was the principal export. The fall in wheat values struck a severe blow to this time-honoured principle, but it must be allowed that the idea still prevails as regards arable-land farming. The changes which have followed the abandonment—at least to a great extent—of wheat growing have been as follows:—

1. A general movement in favour of grass and grazing.
2. A development of dairying, and especially of milk production.
3. A modification of the four-course rotation in favour of rotation grasses, and root and fodder crop cultivation.
4. A great development of potato cultivation.
5. An increased acreage of oats.
6. An impetus towards fruit culture and market gardening.

We have already dealt with the two first of these changes, and turn to the consideration of the others.

EFFECTS OF CLIMATE AND SOIL.—In order to do this effectively we must take as a guide the divisions of England into agricultural provinces, adopted by the Board of Agriculture. These provinces are marked by differences in climate, and are as shown on p. 55.

These groups represent different types of farming. Divisions I and II, if taken together, comprise the principal corn-growing areas and the chief barley-growing districts. Fifteen of them are traversed by chalk hills or downs, and they also comprise the great level tract of the Fen country, and some of the richest land of the kingdom. Bedford, the first mentioned, is noted for its agriculture, and contains between Sandy and Biggleswade an extremely rich tract of soil devoted to the cultivation of exceptional crops, such as pickling-onions, cucumbers, the raising of mangel, swede, cabbage, and turnip seed, and of choice potatoes. It is worth £5 per acre, and is only devoted to corn growing when it is worn

AGRICULTURAL PROVINCES

DIVISION I. 10 Eastern and North-eastern Counties.	DIVISION II. 12 South-eastern and East Midland Counties.	DIVISION III. 10 West Midland and South-western Counties.	DIVISION IV. 10 North and North-western Counties.
Bedford.	Berks.	Cornwall.	Cheshire.
Cambridge.	Bucks.	Devon.	Cumberland.
Essex.	Hants.	Dorset.	Derby.
Hertford.	Kent.	Gloucester.	Durham.
Huntingdon.	Leicester.	Hereford.	Lancaster.
Lincoln.	Northampton.	Monmouth.	Northumberland.
Middlesex.	Notts.	Salop.	Stafford.
Norfolk.	Oxford.	Somerset.	Westmorland.
Suffolk.	Rutland.	Wilts.	Yorks, North Riding.
Yorks, East Riding.	Surrey.	Worcester.	Yorks, West Riding.
	Sussex.		
	Warwick.		

out for other crops. Cambridgeshire, Lincolnshire, Norfolk, and Kent form a group of counties in which the highest farming obtains. Nottingham is the site of the 'Dukeries', or union of four noted ducal properties. Hertford is distinguished by the celebrated Rothamsted experimental station; while Berks, Hants, Oxford, and Sussex are famous for sheep-farming on a large scale. Middlesex boasts of the most approved system of haymaking in the country, and Suffolk is the home of the celebrated Suffolk Punch breed of horses. The Shire horse is bred with the greatest possible success in Beds, Berks, and Lincolnshire, and Northampton grazing is justly celebrated. Essex has suffered in an especial degree owing to its being, or having been, one of the chief wheat-producing English counties. Leicester is famous as the birthplace of the improved Leicester sheep, Long-horn cattle, and the Shire horse, and as the birthplace of Bakewell, the first improver of live stock. Huntingdon forms part of the great level of the fens.

In these counties the rainfall measures about 25 in. per annum, and the climate is bracing, and well suited for agricultural pursuits. They are mostly farmed upon the four-course system, but potatoes are largely grown in south-east Yorkshire, Lincolnshire, and Kent. Beans are almost entirely restricted to this province, and peas are widely cultivated. The climate favours arable cultivation, and rotation grasses are not often allowed to lie a second year. The best quality of both wheat and barley is produced in these counties. The farmers are men of ability and of capital, and great supporters of the London Farmers' Club, Chambers of Agriculture, and agricultural societies. That they are as a rule prosperous there is every reason to believe, as they have adapted their methods to the times. The marshes of Lincolnshire, Norfolk, Essex, Huntingdon, and Kent (Romney Marsh) are abundantly stocked with cattle and sheep, and the metropolis is supplied with beef from them in summer, and from the winter graziers in the same counties during the remainder of the year.

If a line is drawn from Berwick-on-Tweed to the centre of the Isle of Wight, almost the whole of these counties will be found on its eastern side. It is the arable portion of England, the corn-growing area,—comparatively flat and low-lying, in comparison with the more elevated tracts of the west.

Upon the other side of this line will be found the other two divisions. They are of a different nature, being subject to a rainfall of from 30 to 40 in., and in some cases to a great deal more. They are less strictly agricultural, and are rather pastoral in character. If, as in the case of Divisions I and II, we briefly review them, we find in the counties of Dorset, Shropshire, and Wilts, centres of first-rate arable farming. On the other hand, Gloucestershire, Hereford, and Somerset are famous grazing counties. Cornwall boasts a mild and humid climate, which with Scilly contributes large supplies of early vegetables for the London market. In Devonshire agriculture is backward, but a redeeming feature is found in the Red cattle of the north and the lighter-coloured South Devon breed. Worcestershire is the home of orchards, and the source of the best cider and perry; while the market-gardening around Evesham is well worthy of a visit. Some of the best land in the county is found on the middle series of the Old Red Sandstone, in Hereford and Monmouth, and the Hereford cattle form another most interesting feature. Herefordshire is celebrated for its oaks, which have earned the title of Herefordshire weeds. In Division IV, Cheshire not only stands first on the list, but well deserves its position as the theatre of the Cheshire dairy industry and the Cheshire cheese manufacture. The county was severely punished in 1866 by the cattle plague, when no fewer than 32,148 cattle were compulsorily slaughtered, or died, out of a total of 93,044. This must have been a crushing blow, requiring years to recover from. Both the divisions under consideration are mountainous or elevated in character. From the fells and moors of Northumberland and Durham, the hills and dales of West Yorkshire and East Lancashire, the Lake districts of Cumberland, Westmorland, and North Lancashire, we pass southwards into the Peak district of Derbyshire, and the high lands of Staffordshire. Another feature is the distinctly mining and manufacturing nature of almost the whole area.

MINES AND MANUFACTURING TOWNS.—Agri-

culture is interrupted by the coalfields of Northumberland, Durham, Yorkshire, Lancashire, and Staffordshire (the Black Country). There is little coal on the east of our imaginary line, and few hives of industry. Newcastle-on-Tyne, Durham, Manchester, Liverpool, Macclesfield, Sheffield, Leeds, Wakefield, Warrington, Birmingham, and Wolverhampton may suffice to illustrate this point; but in spite of this physical drawback, agriculture flourishes in the near proximity of tall chimneys and collieries. Wolverhampton and Birmingham are surrounded with rich and well-farmed districts, and Shropshire has achieved a world-wide reputation for her sheep. Still, it must be allowed that we pass beyond the domain of agriculture as the principal pursuit when we travel northward and westward, from the level tracts of the eastern and south-eastern counties.

Divisions I and II comprise, speaking of course generally, the agricultural half of England; while Divisions III and IV are manufacturing, mining, and metalliferous, but at the same time agricultural and pastoral. They are succeeded by Wales, with its slate quarries and steam coal, its mountains and its wastes. Shropshire rises into the Longmynd and Wenlock formation, and Staffordshire into primitive pastoral tracts. Corn growing is at a discount, and grass land and milking cows take its place. Such is a general sketch of the four principal divisions into which England may be divided.

Where We have Deteriorated.—We now pass on to consider some of the leading features of farm practice. Details are given under numerous heads in this work, and special articles will be found upon all the principal systems of farming, such as mixed, cattle, sheep farming, &c. (See Farming, Systems of.) It is therefore unnecessary to enter upon such details further.

It is the habit of some of the younger farmers to lay stress upon 'up-to-date' methods, and to speak rather scornfully of what 'might have been all right forty years ago'. This is a great mistake, first because the practice of 'forty years ago' was, if anything, superior to that of the present, and secondly, because in many respects there has been wonderfully little change. English farming has deteriorated in the details of its management. It must be patent to every student of agricultural literature that the centre of interest has entirely shifted. In the early volumes of the Royal Agricultural Society's Journal, drainage, trenching, thin seeding, methods of cultivation, the farming of the counties, occupied most space; whereas now, reports of the stewards, the scientific advisers, and of committees, fill most of the volume. Agricultural discussions are not now devoted to the best methods of cultivation so much as to roads, local rates, railway rates, Acts of Parliament, co-operation, and other subjects of public interest. The farmers are less occupied in the daily management of their farms, and are less attentive to the numberless points which at an earlier period marked the clever manager. Take, for example, the harvest field. The self-binder has done away with careful binding, stooking, and stacking, while the ricks are turned off in such slovenly fashion as would have scandalized a farmer in the early 'sixties. Where is now the barn sheet which used to be spread below the threshing machine to catch every grain of corn? The author well remembers when winnowing was done by candlelight, and the farmer himself measured up the corn. He has heard a farmer rate his bailiff severely for standing upon a young turnip, and he knows by experience that everything was done neatly, orderly, and economically on good farms. A modern farmer may in some cases follow in the wake of his predecessors, but more commonly he is too much from home to attend to such trifles, and leaves them to a foreman.

Our average production of wheat stands exactly where it did when Mr. Chandos Wren Hoskyns wrote his preface to the Royal Agricultural Society's Journal of 1840—in spite of the fact that the worst wheat land has gone out of cultivation. It is also currently believed by older men that sheep were fattened without cake fifty years ago, while now they must have it, or keep lean. Modern agriculture has not improved in its methods, but it has improved in its appliances: in, for example, its choice of artificial manures and feedingstuffs, in its implements, in its live stock, although they require pampering to a degree unheard of at the time now referred to. We now have the advantage of steam cultivation, of labour-saving implements, of scientific instruction. But do these things really bring us better results? Does a knowledge of Mendel's law enable us to breed better cattle than were bred by Charles Colling and Thomas Bates? The writer thinks not; and further, it is the case that the majority of farmers pay little heed to the teachings of science.

As to steam cultivation, it is less widely employed than was expected by its promoters. At a recent meeting of the London Farmers' Club (1908) it was strongly held that the horse is, after all, the cheapest power available to the farmer. The actual cost of horse maintenance is much less than is set forward in many calculations as to costs of cultivation, and besides, the horse is available at all times, and is not nearly so liable to injury or deterioration as a machine. Steam cultivation has settled into its proper position as an adjunct and help in need, but if the tillages can be effected by the teams, the labour is more cheaply performed. As to efficiency, it depends entirely upon the class of land, for although beneficial to stiff and deep soils, steam cultivation is positively injurious to shallow land.

The ordinary rotations of root crops, corn; fodder crops, corn,—maintain their position, and the teamsmen go out and come in as they always did and apparently always will. We cut corn earlier than our forefathers, but the policy is questionable. Fruit should be ripe before it is pulled, but we have for years been told that 'we cannot cut wheat too green'. Research, however, clearly shows that this may easily be done. Wheat must have time to fill its ears, and to develop each grain to its fullest extent. If cut

too soon the grain shrivels, because the nutrient material which was gravitating to the head has been arrested in mid career. The straw is better fodder, but that is only because the nutrient matter is left in the straw; the bushel is heavier because the grains are smaller, and the bran is thinner, to our great loss, as the bran is of equal value with the rest of the grain. Modern science teaches us to grow wheats rich in gluten; but we must remember that richness in gluten often means poverty in starch, and is only relative and not actual richness. Roots involve the most complicated, expensive, and risky cultivation of the whole rotation.

The contrast between the thorough and clean condition of these crops in the north, and the opposite condition often seen in the south, must strike anyone. It is mostly due to climate, but also to the more painstaking cultivation, earlier sowing, and more liberal manuring observable in the north. Mangel wurzel does much better in the southern counties, and its cultivation ought to be more general. The English farmer clings to corn, and not unreasonably, as the cultivation is simple, and *per se* it is cheap. The desideratum is, to cultivate roots either at a direct profit or at a very small loss, for if this is done, the manure derived from their cultivation is obtained at the lowest possible cost.

The farmer is now freed from those restrictions as to cropping and the sale of straw and hay which used to hamper him. From 1st January, 1909, The Agriculture Holdings Act of 1906 came into force, and the English farmer will sit more secure, and enjoy greater freedom than he has ever done before. He appears to be on the high way for a modified form of fixity of tenure, and to be at least likely to be freer from the danger of capricious ejectment.

Great Variety of English Farming.—English farming is sometimes regarded as though the entire country was one 'John Bull's farm', but this is scarcely admissible on account of the different descriptions of farming followed in the various counties. An incorrect impression would at once be given if the northern and north-westerly were added to the southern and south-easterly counties, in order to strike an average. That there are similarities, as well as differences, is perfectly true. There is the same attractive diversity of field and copse, pastures and cultivated fields, sheep and cattle sprinkled over the grass land, and of teams patiently ploughing. But to the experienced eye there are differences of a most substantial character. There are in the south the small holdings and small fields, the numerous hedgerows and the high-backed ridges which characterize clay lands, with cattle and corn as distinctive features, and a preponderance of permanent pasture. There are also the extensive downs or wolds, divided into 1000-acre holdings, and into 50-acre fields, without hedges, and bare of timber. The sheep are no longer seen dotted thinly over pastures, but are collected in mobs between wattled hurdles. The valleys are watered by streams which are used for irrigating meadows. The buildings are thatched, and scattered over the extensive arable land; and catch crops are sown on corn stubbles as soon as the fields are clear of corn. Such is a picture of South Wilts and South Hants.

The scene is again changed, and we find ourselves in endless grass fields, some old, and some newly laid and showing traces of recent cultivation. We are now in a dairy county, it may be in North Wilts or Somersetshire. Again we find ourselves in a perfectly flat country, where the horizon forms a circle around as though we were at sea. The land is black, and carries heavy crops of oats, mustard, rape, and kohlrabi. We are passing through the Fen country of East Anglia. Or we may find ourselves in one of those 'gardens' of England, such as South Derbyshire, Hereford, Warwickshire, or Worcestershire, among orchards and hopyards; or among the rich fruit farms and hop gardens of Kent.

There is no comparison, and very little common feeling, between these various descriptions of farming. The farmers know little of each other, and their conversation relates to different topics. Of what advantage is it, then, to club them together and present figures showing the percentage of cattle to sheep, or of grass to corn, as if England was one huge farm?

Relations to Science.—The relations of English farming to science are in many respects different to what obtain on the Continent. The German is naturally a scientist, but the Englishman is essentially practical. The Continental farmer is more docile as a pupil, while the English farmer at once takes up a critical attitude. New ideas make their way very slowly among English farmers. Take Ensilage for an example. This process is simple and perfectly efficient. Cattle and sheep freely consume the silage, and the risks from wet weather are completely avoided; and yet ensilage does not spread in England. It was introduced to the notice of our farmers in 1873, and was well advertised by the Ensilage Commission. It was adopted by landlords, and recommended by the Press; but the English farmer would have none of it. The smell of it was enough for him, and he stuck to sweet, saleable, assessable hay. Take spraying charlock, and potatoes, as another example. It has taken in some quarters, and we hear it has been adopted in Scotland; but charlock fields still bloom forth like a cloth of gold, and potato blight visits us with wonderful regularity; as yet it is only a small minority who adopt the process for either the one case or the other. The persistent manner in which oldfashioned ploughs, harrows, cultivators, and drills hold their own is also remarkable, in spite of agricultural shows and voluminous reports. One of the points in common among all English farmers is the veneration with which they regard farmyard manure. Their high estimation for this fertilizer is well founded, and it by no means follows that it is extravagant. It is, however, associated with erroneous views as to 'artificials', which ought to have been long since exploded. There are lingering doubts that they exhaust the land, that they cause swedes to rot, and that they may injuriously affect stock.

The English farmer is not devoid of prejudices, as the above examples show. Like the deaf adder he refuses to hear the voice of his charmer, charm he never so wisely. His pre-eminence as a cultivator, and as a breeder of stock, is admitted by all, but these achievements cannot be attributed to study or reading. They have been transmitted from father to son, and communicated from mouth to mouth, in private intercourse, on the market, and by observation. While all this is true, it must not be thought that the farmer is proof against advice or teaching. A thoroughly practical idea catches on rapidly. Take, for example, the general adoption of the self-binder, the hay tedder, the horse rake, the elevator, and the steam threshing machine. Or in the case of artificial manures, the general use of superphosphates, basic slag, nitrate of soda, and kainit. Ideas sometimes even run too fast, as for example in the agitation for the repeal of the malt tax, and the futile cry for pure beer.

CONCLUSION.—English farming is inferior to Scotch farming in several points. In the cultivation of roots it is behind the north, as it is also in the cleanness of the land, the trimness of the fences, and the economy in manual labour. English farming is often slovenly or even wasteful. There are few farms in a perfect state of cultivation, and no district which can compare with East Lothian in the intensity of its cultivation and its striking effect upon the senses. It would surprise many English farmers, who take wide and crooked untrimmed fences as a matter of course, to see the thorn hedges of Lothian, 3 ft. high and about 1 ft. thick, standing on the flat surface, with not a weed or blade of grass at their roots. The English farmer as a rule is careless of his hedges, and regardless of various forms of waste, such as, for example, allowing the goodness of farmyard manure to be washed out by the rain, and implements to remain out in all weathers. Still, and we trust sufficient has been advanced to substantiate the statement, the English farmer has surmounted many difficulties. He has brought the land into a high state of fertility, chiefly by the use of farmyard manure; he has created unrivalled breeds of live stock, and made their merits felt all over the world. He is quoted in all the foreign textbooks as an example, and he has brought English agriculture up to such a pitch of excellence that it is almost without a rival.

The author has endeavoured to give a general impression as to what English farming really means; and if any reader is disappointed by a dearth of statistics, he must remember what Lord Beaconsfield once said, namely, that there is nothing so delusive as 'facts'—except figures. Besides this characteristic epigram, it may also be said in extenuation, that the agriculture of England is so diversified as to defy description within the limits of one article. The great variety of climates in England, entailing a fall of 20 in. of rain in one locality and over 100 in. in another (Seathwaite); the enormous difference in productive power between the rich soils of South Lincolnshire or the deep soils of Kentish hop gardens, and the thin soils of the Upper Chalk or of the inferior Oolite; the situation below the sea level in many parts of East Anglia, contrasted with an elevation of over 1000 ft. in Shropshire, Hereford, and many western counties; the retentive character of clays in Worcestershire and Warwickshire, requiring four horses, in contrast to the sandy soils of Norfolk, which were humorously said to only require to be ploughed by 'two buck rabbits and a claspknife'; and lastly, the differences between the arable districts and those entirely devoted to grazing; and of others devoted to potatoes, fruit, and hops;—these constitute almost insurmountable difficulties in the way of a comprehensive description of English farming. [J. WR.]

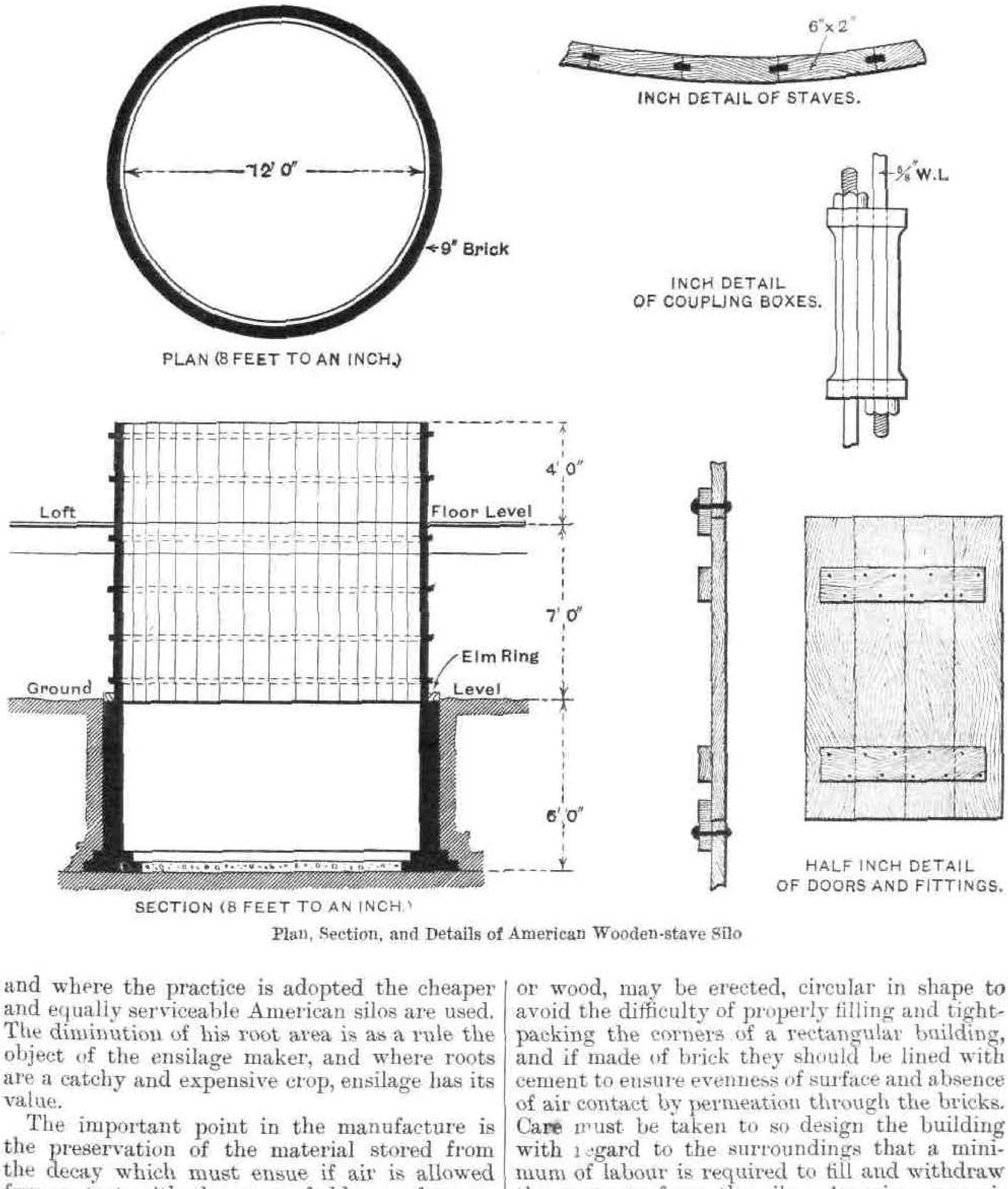
Ensilage.—The manufacture of ensilage (a word meaning literally storage in pits, from Span. *ensilar*, from *en*, in, *silo*, Lat. *sirus*, Greek *siros*, a pit) consists in the preservation of green fodder in a pit, stack, or silo, with the view of its use at a time when green succulent fodder is not available from other sources. Ensilage, therefore, as an article of food for stock takes the place of roots in winter feeding, and although its manufacture is substituted for that of hay in a very wet season, it is not as a hay substitute that it is used for feeding purposes. Error in regard to this led in the first place to a false estimate being made of the value of ensilage, as it can never be conceded, even by the most enthusiastic advocates of the system, that ensilage can be compared with good hay; but when, owing to weather conditions, good hay cannot be made, a useful fodder can be made of ensilage, which as an article of food is more valuable than bad, washed, and innutritious hay. Another exaggeration was also indulged in by the advocates of ensilage, or perhaps by those who misunderstood their intentions, that any rubbish—hedge bottoms, nettles, weeds of any description—would, if filled into a silo or made into ensilage, emerge first-class fodder. One cannot make 'a silk purse out of a sow's ear', and what is put into a silo will come out therefrom altered in palatability and perhaps in digestibility, but with no great increase in its absolute feeding value. Having at the outset got rid of these fallacies, which have done much to retard the rational use of ensilage, we may consider the subject under the following heads:—

1. Methods of manufacture—silo, pit, or stack.
2. Suitable crops for ensilage.
3. Changes taking place during manufacture.
4. Use of ensilage for stock food.

In England, ensilage was first made in 1882, but the process is of considerable antiquity—grain was stored centuries ago in the East in pits; in France and Germany fodder crops, rough grass, mangel tops, &c., were, and are, pitted and preserved from contact with air; and in this country it has been the practice to store wet brewers' grains in pits, for use during the winter; but ensilage making was actually introduced into this country from France, where the system was thoroughly described in Manuel de la Culture et de l'Ensilage des Mais et d'autres Fourrages verts, par Auguste Goffart. In America the system is widely practised, owing

to the difficulty of obtaining root crops (mangel, swedes, cabbage, &c.) for winter feeding, and most of the research work on the subject is due to American workers. In this country, experiments and analyses of the methods and results have been made, and E. J. Russell has conducted, at the Wye Agricultural College, an exhaustive investigation on the changes taking place in the silo and the conclusions to be drawn therefrom, to which researches allusion will be made later on; but it cannot be said that in Great Britain the system has generally been adopted—the root crop is of such cultural and feeding importance, and is as a rule a comparatively certain crop, that succulent winter feed is generally obtainable, and it is not often that the conditions are such that a reasonable quality of hay crop cannot be secured.

In 1882, when ensilage was being boomed, large sums were expended in special buildings and plant, and at the present day most of these are either used for other purposes or discarded,



Plan, Section, and Details of American Wooden-stave Silo

and where the practice is adopted the cheaper and equally serviceable American silos are used. The diminution of his root area is as a rule the object of the ensilage maker, and where roots are a catchy and expensive crop, ensilage has its value.

The important point in the manufacture is the preservation of the material stored from the decay which must ensue if air is allowed free contact with the green fodder—a fermentation is required, due to chemical changes induced by bacteria and enzymes, and it is essential that close packing of the sufficiently ripened material in an air-tight receptacle be ensured. Special buildings, silos, of brick, stone, or wood, may be erected, circular in shape to avoid the difficulty of properly filling and tight-packing the corners of a rectangular building, and if made of brick they should be lined with cement to ensure evenness of surface and absence of air contact by permeation through the bricks. Care must be taken to so design the building with regard to the surroundings that a minimum of labour is required to fill and withdraw the contents from the silo—American experience states that 'a silo with a cellar is wholly inadmissible'. Stone and brick buildings are expensive to erect, and the capital sunk in their erection is during eight months of the year practically dead and earning no interest. The Ameri-

can wooden-stave silo is a much cheaper erection, and the following are the details of the Wye College silo (Journal S.E.A.C., No. 12, March, 1903, p. 42). The points which subsequent experience has shown to be faulty are the underground part and the system of withdrawal of the ensilage. The soil and subsoil being solid chalk, there was no danger of underground water being touched, and a circular hole 14 ft. in diameter and 7 ft. deep was excavated. The bottom was laid in cement on 4 in. of broken rubble, and the sides carried up in 9-in. brickwork on two courses of footings to ground level and carefully pointed inside with cement mortar, the internal diameter measuring, when complete, 12 ft. in the clear. On the top of the brickwork the staves were placed in position; these consist of 6 in. by 2 in. well-seasoned fir, grooved to admit a hardwood slip or tongue for the purpose of making a tight joint. The staves themselves are given a slight bevel on their inner surface in order that they may conform more truly to a circle, but in a silo of larger diameter this would not be necessary. It is especially important that the feet of the staves be kept properly in position; *i.e.* they should be exactly flush with the brickwork at the point of junction. Should they slip back, the angle of the projecting brickwork will cause an unequal settlement of the silage. An elm ring 5 in. by 2½ in. was used to ensure stability, and it was held firmly in its place by means of short sleepers embedded in the ground and notched at their upper ends to receive the ring. Six ⅝-in. circular straps, each made in three lengths, were employed to hold the main body of the silo together, and at the junction of each portion a coupling box was provided, with threads and nuts for adjustment in case of any alteration in the staves through these swelling or shrinking. To make the doors, which should be put at convenient places and depths for the facility of emptying or for withdrawing the silage, an opening of the desired size is sawn out, and the portions thus removed are placed in their former relative positions and firmly braced together by bolting them to a couple of battens. The door thus made is held in the opening by the pressure of the ensilage, and is prevented from falling outwards by means of a portion of 6 in. by 2 in., bolted to project over the top and bottom of the opening, and forming a rabbet against which the door can rest.

In filling the silo with whatever materials may be utilized, it is essential that every care be taken to get those materials into such a condition as will ensure close packing and a considerable amount of consolidation. The cutting of the green crops into short lengths or chaffing is generally advisable, and the contents of the silo should be well trodden round the circumference, or if a square shape be used, into the corners. Many crops have been suggested for ensilage manufacture; Italian Rye Grass, mixed beans, peas, oats, and vetches, trifolium, maize, can all be utilized; but it is most desirable that a considerable degree of maturity of the crop be attained before ensiling, otherwise there is considerable waste during the process of fermentation in the silo. It is not necessary to go to the expense of a separate building for the manufacture of ensilage; the material may be stacked in either a long or chaffed condition, and the conditions for the necessary fermentation obtained by consolidating or compressing the stack by weights placed on the top, wire ropes passed over the stack and tightened at the sides by ratchets, or other means to produce these conditions. In the making of stack ensilage there is bound to be a considerable amount of waste on the top and in the outsides, where contact with air is unavoidable, but this waste need not amount to a great proportion of the bulk. Suggestions have been made to avoid the expensive and uncertain root crop by the extended growth of leguminous crops, some of which would be ensiled, and so to increase the economic accumulation of nitrogen in the land; and it would seem that on certain classes of soils in certain districts such a practice would be valuable, and an analysis of the labour bill of such a system does not reveal as extravagant an expenditure in that direction as would appear on first sight; but it yet remains to be proved whether stock will do continuously well on ensilage feeding, especially when the condition of the ensilage is of such a variable nature as the changes of climate and seasons must in this country render it. It is possible that some system of ensilage may lead to the more economical use of straw on the farm, and that an admixture of straw and green fodder may be stored under such conditions as will cause a breaking down of the cellulose of the straw, and the consequent rendering of the cellulose to a more digestible condition. In former years some distinction used to be made between sour and sweet ensilage, and the respective conditions of manufacture; but the most palatable and digestible form of ensilage seems to be a mixture of these forms, or at all events a product of a possibly intermediate fermentation. In feeding ensilage to dairy stock, great care must be taken that every chance of the absorption by the milk of the strong odour of the ensilage be avoided; it should be fed after milking, and should not be allowed to be in the same building as the freshly drawn milk, and the milkers should take care that their hands, if they have been engaged in working with the ensilage, should be thoroughly cleansed before milking. Ensilage making is more economical for large than for small farms, the smaller the quantity made the greater the proportion of waste; and of course in the carrying of so much fodder green there is more labour and horse work than in haymaking.

Russell (Journ. Agric. Sc., vol. ii, pt. 4, p. 409) sums up the chemical changes during the making of maize ensilage as the disappearance of the sugar, of some of the less resistant celluloses, and of part of the protein, and considers the living maize cell and enzymes to be the cause of the essential changes, micro-organisms playing a secondary and non-essential part.

[M. J. R. D.]

Entail.—1. England. — The word 'entail' is not a technical legal term. It is used sometimes to denote an 'estate tail', which is an

expression derived from the French word *tailler*, to cut or abridge, from the inheritance being by the statute De Donis (13 Ed. I, c. 1) cut down and confined to the heirs of the body of the first taker, and thus descending in a course of perpetual descent from father to son. The inconvenience of strict entails created under this statute was, however, soon felt, and in the reign of Edward IV a means was discovered of destroying entails by means of a fictitious suit, whereby, under the name of a 'common recovery', the issue of the tenant in tail and all remainders expectant on the estate tail were barred, and he became possessed of an estate in fee simple which he could dispose of as he pleased. The legislature has now by the Fines and Recoveries Act, 1833 (3 and 4 Will. IV, c. 74), substituted for a common recovery a simple deed executed by the tenant in tail and enrolled. By this means a tenant in tail *in possession* may defeat the claims of his issue and of all persons having any estates in remainder or reversion. If, however, the tenant in tail is not in actual possession of the property, but entitled merely in remainder expectant on the determination of some antecedent freehold interest, *e.g.* where A is entitled for life with remainder to B in tail, he cannot, except with the consent of the owner of the antecedent estate, do anything more than bar his own issue, leaving the reversions and remainders expectant upon the failure of his issue intact. The estate so created by barring the issue only of a tenant in tail in remainder is called a 'base fee', which, during the continuance of such issue only, will be subject to the dispositions of the person who has barred the entail, or descend to his heirs in fee simple.

The word 'entail' is perhaps popularly more often used, not to denote the interest in land known to lawyers as an estate tail, but to denote what is called a 'strict settlement' of land, as on A for life with remainders over for life or in tail, by means of which family estates are preserved for many generations. Such settlements have to be renewed from time to time, as the law forbids a perpetuity, and does not allow an entail any further than can be effected by giving estates to the unborn children of living persons, an estate given to the children of an unborn child being treated as absolutely void. The system commonly adopted is to confer an estate for life only on A with remainder to his first and other sons successively in tail male with other family remainders over. During A's life the estate cannot be disposed of by him, and his eldest son when he attains majority, being a tenant in tail in remainder during his father's lifetime, can, except with his consent, only bar the entail so as to create a 'base fee' (see above). Usually on the attainment of majority by the eldest son the estate is resettled by mutual consent of father and son, reserving to the father his original estate for life, and abridging the son's estate tail by converting it into an estate for life expectant on the death of the father, with probably some rent charge to the son by way of intermediate allowance, and by conferring, on the son's death (subject to a provision for his wife and younger sons and daughters), estates in tail male upon his (the son's) first and other sons in succession. A similar resettlement will take place in the next generation, and so in the ordinary course of events the land may remain in strict settlement for many generations, though the entail might come to an end if no resettlement were made for a generation, or if a father tenant for life and his eldest son on coming of age concurred in disposing of the property, as they might do by means of a disentailing deed under the Fines and Recoveries Act.

To remedy the inconveniences which may result from the inalienability of land under strict settlements a series of Acts of Parliament, called The Settled Land Acts, 1882 to 1890, have been passed, 'for facilitating sales, leases, and other dispositions of settled land, and for promoting the execution of improvements thereon'. These Acts enable tenants for life of settled land to sell or exchange the property the subject of the entail, the entail being transferred to the purchase money or the land taken in exchange. They also contain provisions for the application of capital moneys produced by sale of part of a settled estate or otherwise to the carrying out of improvements on the settled land retained, and generally enable the owner for the time being to dispose of or deal with the property so as to turn it to the best account, care being taken at the same time to preserve the *corpus* of the property for the benefit of his successors on whom it will devolve under the settlement.

[A. J. S.]

2. SCOTLAND. — Entails were given statutory recognition by the Act of 1685, whereby it was provided that anyone might entail his estate and substitute heirs in the entail, with such conditions and prohibitions as he should think fit, provided the deed contained irritant and resolutive clauses to fortify the prohibitions, was recorded by warrant of the Court in the Register of Tailzies, and was completed by Sasine—now by recording it in the Register of Sasines. The subjects of a deed of entail are lands, houses, teinds, salmon fishings, &c. Moveables cannot be the subject of an entail, except as regards money destined to be laid out in the purchase of land which is to be entailed, or received from the sale of an entailed estate. The essential conditions of a strict entail are: (1) that the lands are to be transmitted to a line different from the legal order of succession, since 'an estate which descends according to the succession appointed by law cannot be made subject to the fetters of an entail'; (2) that it contain the three cardinal prohibitions against (*a*) alienation of the estate, (*b*) the contraction of debt, and (*c*) alteration of the order of succession, or what is now equivalent, viz. a clause expressly authorizing registration of the deed in the Register of Tailzies, which is held to imply the inclusion of these prohibitory clauses. In addition to the cardinal prohibitions the entailer is at liberty to add such other conditions or restrictions as he please, and if they are properly fenced, as will be presently explained, and are not contrary to public morality or general policy,

they will be enforced in the same way as the cardinal prohibitions. It is necessary to a strict entail that it contain all three of the cardinal prohibitions, and if for any reason it is defective in any one prohibition, it is invalid and ineffectual as regards them all. (3) The prohibitive clauses must be fortified by (*a*) an irritant clause whereby any act or deed prohibited is irritated or annulled, and (*b*) a resolutive clause whereby the contravener's rights are resolved or forfeited. But in the case of entails made subsequent to 1st August, 1848, an express clause authorizing registration in the Register of Tailzies is held to imply irritant and resolutive clauses, which consequently do not need to be expressed in the deed.

The restrictions placed on the use of land by the fetters of a strict entail were found to be so detrimental to good management and productive of such injustice that successive Acts of Parliament have modified the effect of the cardinal prohibitions, so that, under the present law, practically the only one that remains is that against altering the order of succession, since extensive powers are now given for disentailing and selling the estate. Nevertheless, so long as the estate is not disentailed, the heir in possession is limited in his rights as compared with a fee-simple proprietor. The powers conferred on him by statute are as follows, viz.: He may (1) disentail the estate, either with or without the consent of the next heir or heirs, according as circumstances demand; (2) sell (*a*) with or without consent, as the case may be, for payment of the entailer's debts, or for debts which are allowed to be charged on the estate, *e.g.* provisions for children, &c.; (*b*) to public companies acquiring the estate or part thereof compulsorily; or (*c*) generally by order of the Court, without consent, if the money is to be tied up in the same line of succession as the estate; (3) excamb portions of the estate; (4) feu out or grant leases, provided they do not exceed the period allowed by the deed of entail or by statute; (5) borrow money on the security of the estate to defray the cost of improvement expenditure thereon; and (6) grant provisions for widows and younger children. The heir apparent has also power, with consent of the heir in possession, to make provision for his wife and children. The heir in possession is not entitled to cut down trees which are required for the reasonable enjoyment of the mansion-house, or which are not ripe for cutting, but he may thin the plantations in the ordinary course of management and sell the mature wood. He is also entitled to work the minerals or lease them out. He is not entitled to lease the mansion-house, policies, or fields round the house.

The powers of management or sale must be exercised in strict formality with the terms and conditions of the entail, or with the powers conferred by statute. 'Each heir in turn takes the estate subject to all real rights and burdens which have been validly laid upon it by his predecessor, and entirely free from all such as are invalidated by the fettering clause, and also from all liabilities which stand upon personal obligation and have not been made to affect the estate itself.' While, according to Scots law, a lease is a personal contract, it is, if followed by possession, capable of being made a real right affecting the estate; and if it does not exceed the period allowed by statute, it is binding upon the succeeding heirs of entail, although a mere contract to grant a lease, not followed by possession, would not be so. But personal obligations are not binding on such heirs who take their interest in the estate from the entailer and not from the preceding heir, from whom they take nothing. This doctrine has been given effect to in the recent Ardery sheep-farm case, which has excited great interest in the agricultural world. In that case the heir of entail in possession of an estate in Argyllshire granted a lease of a sheep-farm which *inter alia* contained the condition that the proprietor would, on the termination of the lease, take over the sheep stock from the tenant at the same price as he had paid on entry. On the death of the grantor of the lease the next heir of the entail intimated that she repudiated any obligation to take over the sheep stock, and the tenant raised an action seeking declarator that this obligation was binding upon her. The Court of Session decided—and on appeal their decision was upheld by the House of Lords—that the obligation was, in its true character, a personal contract over and above the lease, and therefore ineffectual as against the succeeding heir of entail, who did not represent the contracting owner. This decision will have very far-reaching effects both on landlord and tenant unless some alteration is made on the existing law. The Scottish Chamber of Agriculture has already framed a Bill providing that all obligations, undertaken by an heir of entail in possession, in the *bona fide* management of the estate, to take over stock, cropping, or dung shall, in case of his death before complete fulfilment of the obligation, be binding on the heirs succeeding to the estate, to the extent to which they derive benefit from the succession. It is, however, doubtful whether such a Bill would pass, and whether any such limited amendment of the law is desirable. It would probably be better that the whole question of the law of entail be reconsidered in light of present-day knowledge and requirements.

[D. B.]

Enteritis (Inflammation of the Bowels).—This malady is peculiarly fatal in the horse, but all animals are liable to it. It may be confined to the large bowel, or the first and smaller portion, or both may be involved. Commencing in the lining membrane, it extends outwards through the substance of the gut. It is often impossible to assign the cause, but it is observed to follow on colic, impaction, excessive fatigue, wading through mountain streams of icy cold water, the consumption of bad fodder, and both vegetable and mineral poisons. So many cases arise without any of these contributing factors, that we can only confess our ignorance and suppose that there is some one chief source of enteritis not discovered. The symptoms are commonly mistaken for those of colic, and resemble them in the presence of abdominal pain,

but it is of a different character. There is undoubtedly a preliminary period of shivering and staring coat (see RIGORS), but this is often unobserved, and the first attractive symptom is loss of appetite great depression of spirits, accelerated breathing, the voiding of small quantities of dung at rather frequent intervals, and of small shining balls such as we associate with constipation. The symptom common to enteritis and to colic is the pawing or scraping the ground, and looking round uneasily at the flank; and, unfortunately for the patient's prospects of early treatment, the half-hearted manner in which the subject of enteritis does this misleads the attendant, who deems it but slight griping which may have followed on too copious a draught of water or other substance calculated to provoke indigestion. It is important that the horse-owner should differentiate, and he should note that the pain of colic is more severe and intermittent (see COLIC), while that of enteritis is continuous; that the visible membranes are injected and indicating febrile disturbance not usual in gripes; and that the temperature is raised and maintained at some 3 to 5 degrees above normal, while pulse and temperature are not affected in the average case of colic; and in the intermissions of pain the animal is quite himself. The mouth is dry and clammy in enteritis, and the extremities vary in temperature, one limb being cold and others warm. If the disease is not arrested in its progress the patient droops his ears, breaks out into patches of sweat, trembles, and falls, probably to die without struggling. The belly assumes the appearance of having been pressed upwards, and as a consequence bulged slightly outwards; in this differing from flatulent colic, which see.

Treatment consists in alleviating pain by opium and belladonna, as draughts, hypodermic injections, and clysters per rectum, and warm compresses to the belly. Young, full-blooded horses may be bled from the jugular vein when first attacked, but not later. The constipation should not be combated by purgatives, but time allowed the bowels to regain their peristaltic movements when pain has subsided and a laxative diet has favoured a pultaceous condition of the contents. [H. L.]

Entomology, Economic. — Economic entomology is the practical application of the study of the insect world in relation to man, his stock and crops. The name entomology is really only applicable to the study of the true insects, but under the name Economic Entomology other creatures are also treated, such as Ticks, Red Spiders, and Gall Mites, Millipedes, and even Woodlice (which are Crustacea) and Eelworms. The term to include all these should be Economic Zoology, for Entomology only deals with the six-legged animals.

The subject, for economic purposes, is divided into two parts: (1) the tracing of the cycle of the insect's life so as to find out the weak points, where we can assail it when doing damage; and (2) the best means of preventing that damage, and of destroying the pest when present.

HISTORY AND LITERATURE.—Like all branches of science, economic entomology has made vast strides during the last twenty-five years. It entered into real life in 1800. Previous to that date we find only a few isolated papers on applied entomology in relation to agriculture.

Some papers on noxious insects occurred early in the 19th century in the Transactions of the Linnæan Society. In 1829 appeared a work by Joshua Major, A Treatise on the Insects most prevalent on Fruit Trees and Garden Produce, full of interesting and useful matter. In 1841 a series of valuable papers were commenced by John Curtis, entitled Observations on the Natural History and Economy of the Different Insects affecting Crops, and in 1860 appeared his still standard work on Farm Insects. Curtis was the first to place agricultural entomology on a sound basis in this country. Westwood also wrote some valuable papers from 1869 to 1888, which appeared in the Gardeners' Chronicle. The subject was officially recognized in this country in 1886, when Mr. (now Sir Charles) Whitehead was appointed adviser to the Privy Council, and later, at its inception, to the Board of Agriculture, and he issued a number of reports and leaflets. From 1876 to 1893 the Royal Agricultural Society had the honorary services of Miss Eleanor Ormerod, who issued at her own expense a series of valuable annual reports, mainly composed of observations sent by her numerous correspondents. In 1893 some of the county councils recognized the importance of economic entomology, and appointed lecturers to visit the rural districts.

Amongst the more important recent British works of reference and reports may be mentioned the following: A Manual of Injurious Insects, 2nd ed., 1890, E. A. Ormerod; A Handbook of Insects injurious to Orchard and Bush Fruits, 1898, E. A. Ormerod: The Insect and other Pests of Orchard, Bush, and Hothouse Fruits, 1908, F. V. Theobald; A Textbook of Agricultural Zoology, 1899, F. V. Theobald; Annual Reports of the Zoologist Royal Agricultural Society of England, Journal Royal Agricultural Society, C. Warburton; Annual Reports on Economic Zoology, Journal S.E. Agricultural College, 1895-1908, F. V. Theobald; 'Reports on Injurious Insects observed in Ireland', Economic Proceedings of the Royal Dublin Society, 1901-7, G. H. Carpenter; Reports of the Woburn Experimental Fruit Farm, 1900, 1906, 1908, Duke of Bedford and Spencer U. Pickering; Journal of the Board of Agriculture; and the Journal of Economic Biology.

The following works from the Ray Society's publications also are of economic importance: A Monograph of the Coccidæ of the British Isles, 2 vols., 1901, Robert Newstead; A Monograph of the British Aphides, 4 vols., 1875, 1877, 1880, 1882, G. B. Buckton. The latter, however, is out of date, and inaccurate.

A considerable amount of information useful in Britain will also be found in the publications of the U.S.A. Department of Agriculture.

Amongst the more important Continental works of reference may be mentioned Die Pflanzenfeinde aus der Classe der Insekten, 1874, J. H. Kaltenbach; Praktische Insektenkunde, 1879-80, E. L. Taschenberg.

Much valuable information may also be gained from the Colonial reports on Ticks, issued by the Department of Agriculture of the Cape of Good Hope, by C. F. Lounsbury, as well as on other injurious Arthropods common to Africa and Britain; the various reports of Mr. Froggatt, Government Entomologist of New South Wales; The Destructive Insects of Victoria, three vols., 1893, 1900, 1904, C. French; and the Reports of the Government Entomologist and Botanist of Canada (Department of Agriculture), J. Fletcher, 1895–1908. Concerning forestry, we may mention Forest Entomology, 1908, A. T. Gillanders; and various papers in the Journal of the Royal Arboricultural Society and the Journal of the S.E. Agricultural College.

POSITION OF AN INSECT IN THE ANIMAL KINGDOM.—The position of an insect in the animal kingdom comes in the great phylum Arthropoda or that of the jointed-limbed animals. Arthropoda are animals belonging to the Invertebrata, and can be told by their bodies being divided up into a number of rings or segments, composed of an upper and lower moiety, and by their appendages, composed of a number of segments united by distinct joints; the jointed organs of locomotion are always attached to the lower surface of the body; the skin is hardened by the deposition of either calcareous salts (Crustacea) or of chitin (Hexapoda).

The body of the Arthropod is composed of three regions—head, thorax, and abdomen.

This great phylum Arthropoda is divided into four groups:—

1. *Crustacea* (Crabs, Lobsters, Shrimps, Woodlice, &c.).
2. *Myriapoda* (Centipedes and Millipedes).
3. *Arachnoidea* (Spiders, Mites, Scorpions, &c.).
4. *Hexapoda* (true insects).

The characters of these are as follows:—

Crustacea.—Head and thorax fused into one piece; organs of locomotion on most of the segments; two pairs of antennæ; respiration branchial; mostly aquatic.

Myriapoda.—Head separate from the rest of the body; one pair (Centipedes) or two pairs (Millipedes) of legs to each segment (except on the first three).

Arachnoidea.—Head and thorax either fused (Spiders) and distinct from abdomen, or head separate from the body (Acarina); either four or two pairs of legs.

Hexapoda.—Head, thorax, and abdomen distinct; legs six in number, attached to the thorax.

Thus a true insect or hexapod can be told by the number of its legs (six), a spider or mite by having eight or four, a centipede by having one pair on each segment, and a millipede by having two pairs on all but the first three rings of the body.

Economic entomology really deals only with the six-legged animals. The six legs, which are true-jointed appendages, are often augmented in the immature stage—the larva—by paired soft processes called prolegs or sucker feet. It is still general, however, to deal with all Arthropods under economic entomology.

DEVELOPMENT OF AN INSECT.—Most of the Hexapoda pass through two stages after leaving the egg and before becoming adult, namely the larva and pupa. The life-history of an insect deals with these stages, namely the egg, larva, pupa, and adult. The egg constitutes the em-

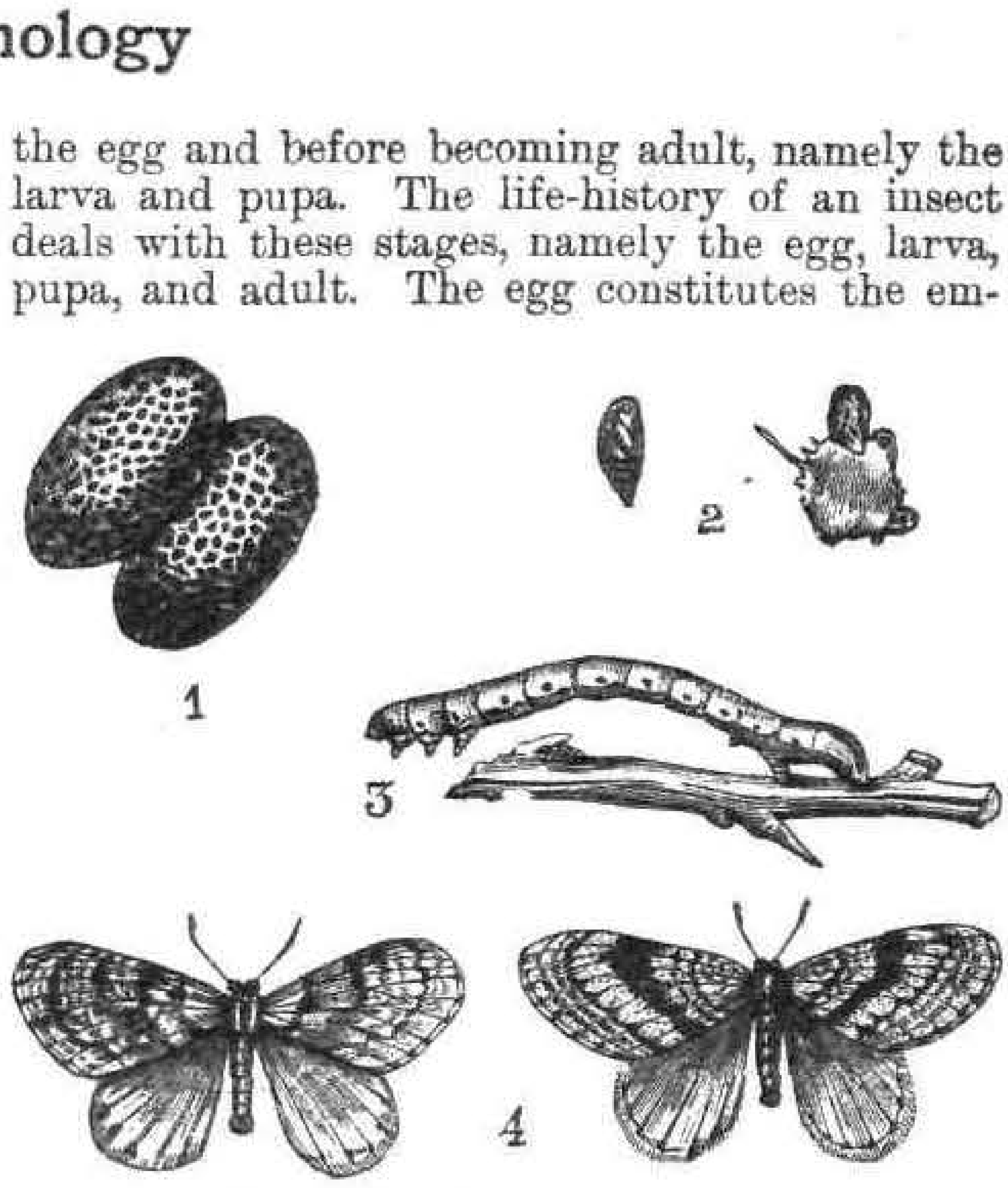


Fig. 1.—Complete Metamorphosis

1, Ova. 2, Pupa and cocoon. 3, Larva. 4, Adult males of the Winter Moth.

bryonic development, with which we are not concerned. The post-embryonic stages—the larval and pupal—vary considerably. The larval stage is the period of growth, the pupal the

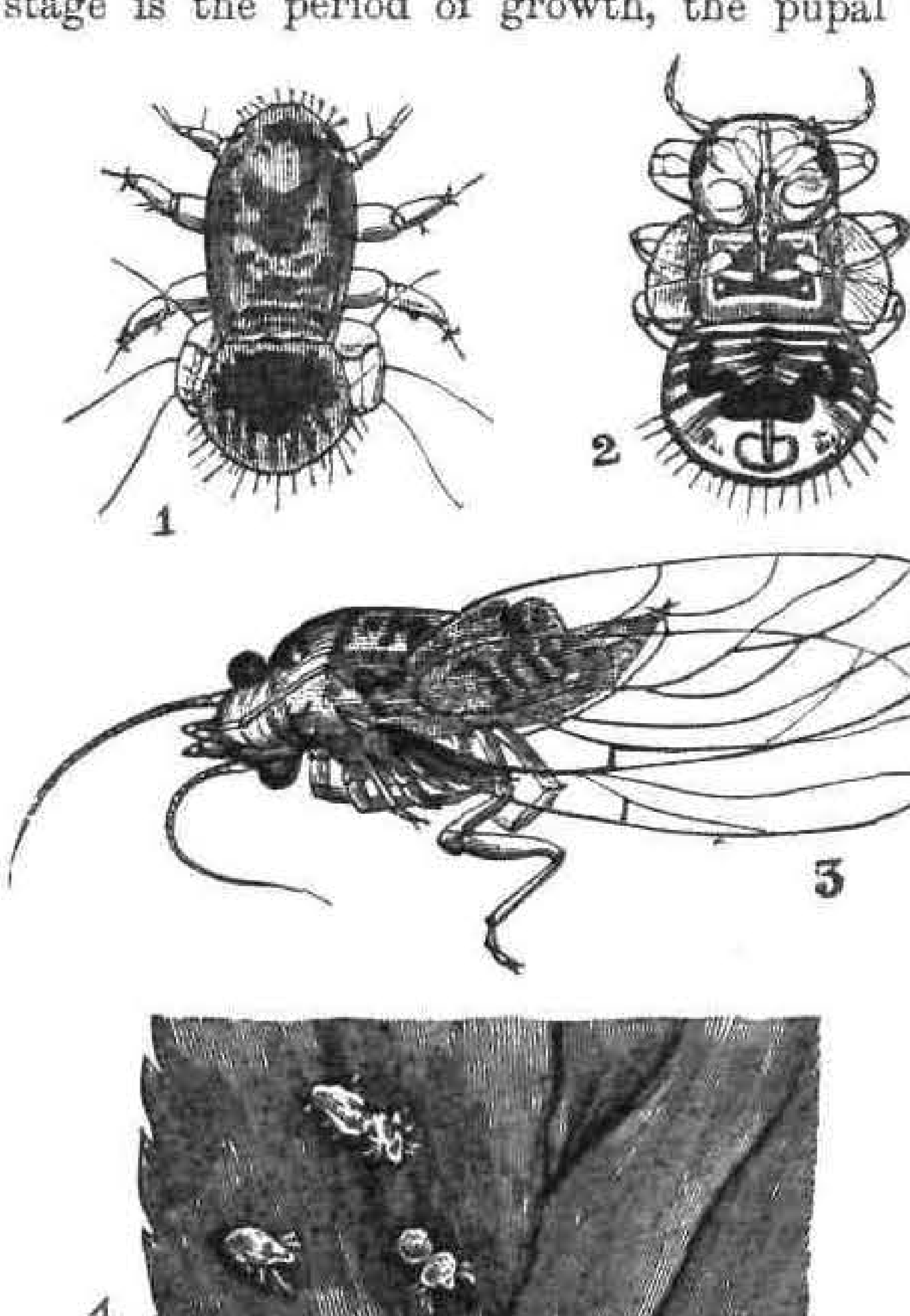
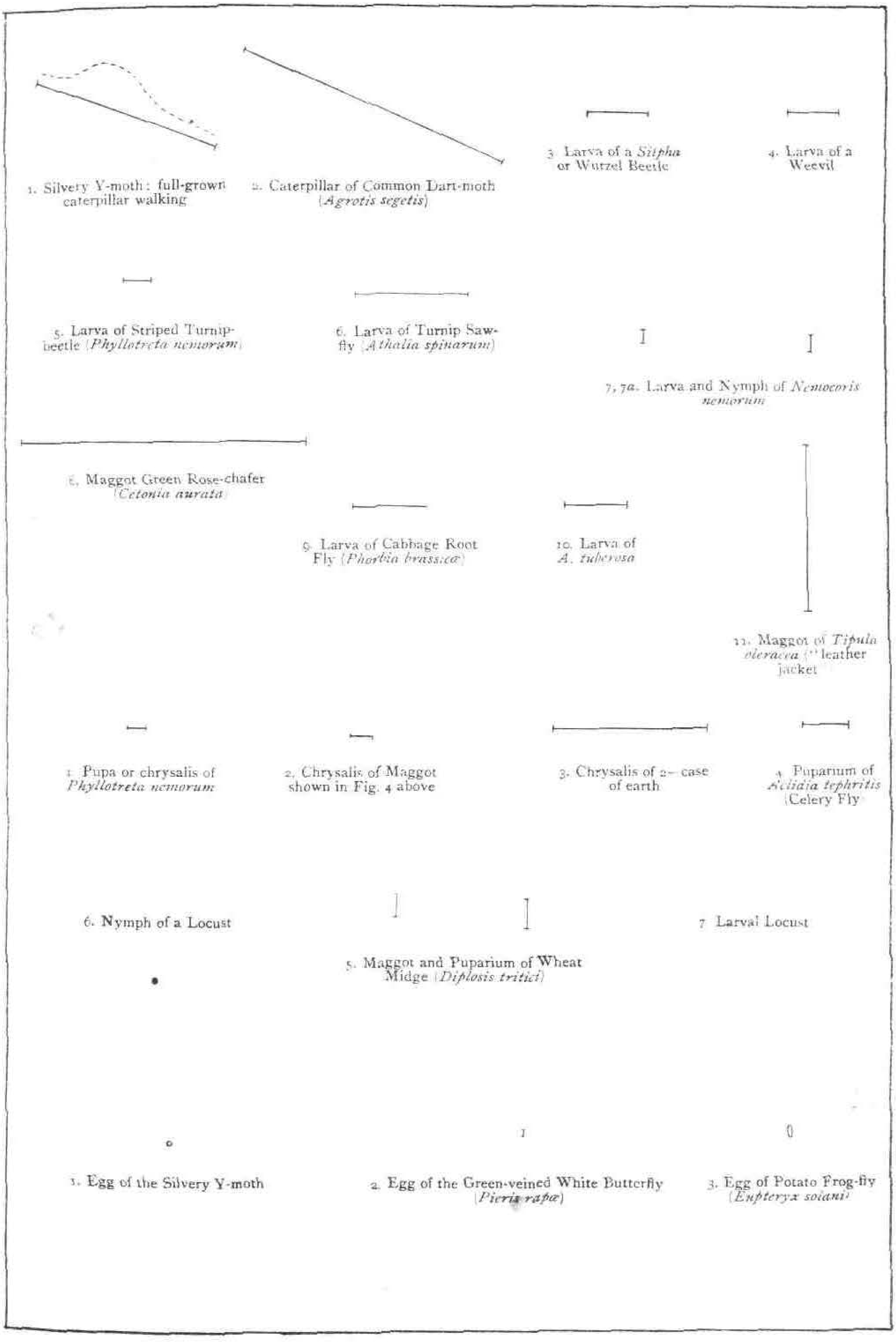


Fig. 2.—Incomplete Metamorphosis

1, Larva. 2, Active nymphs, and 3, adults of Apple Sucker (*Psylla mali*). 4, Cast skins of pupæ.

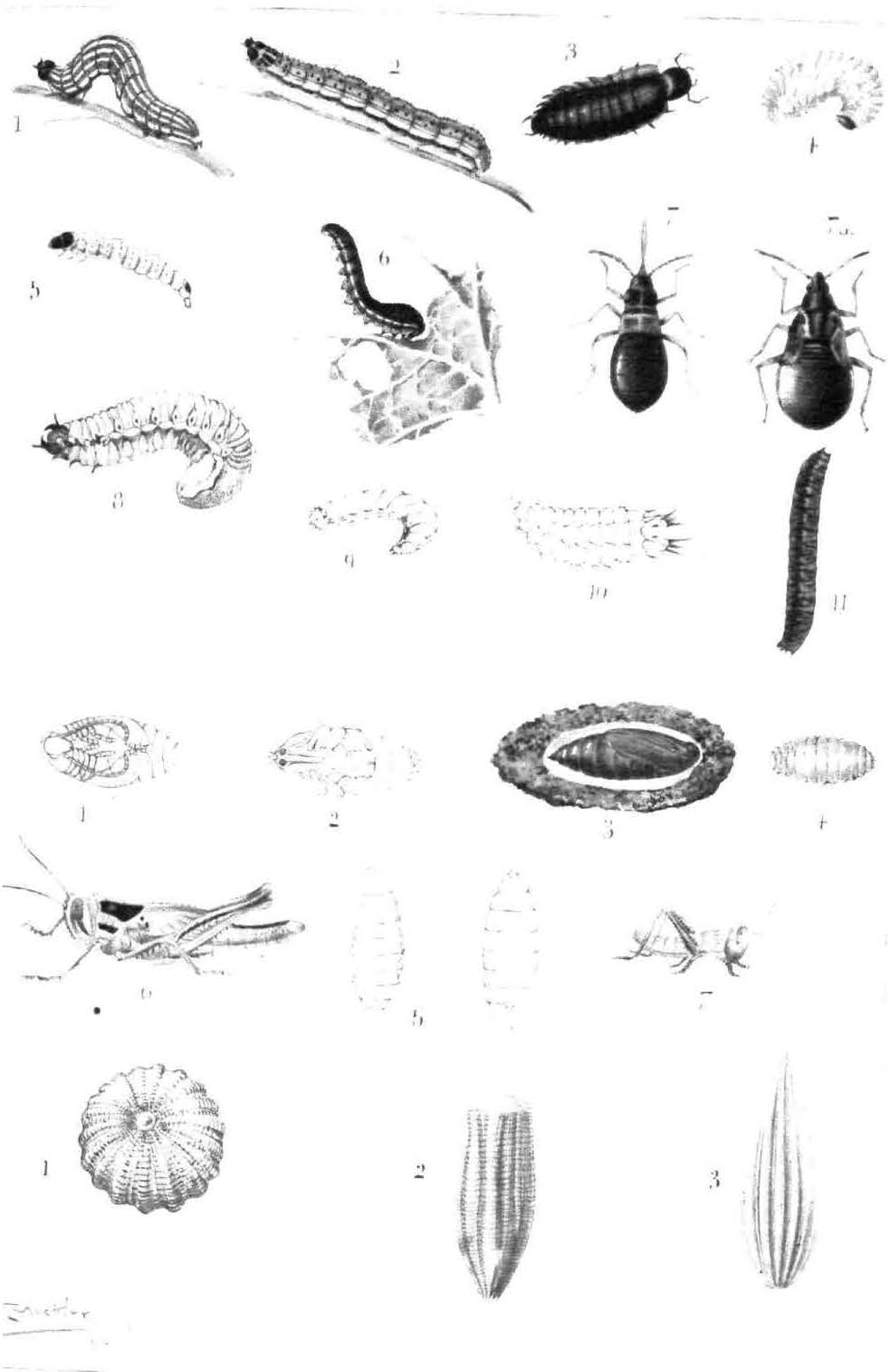
period of change or metamorphosis—the period when the larva is transformed into the adult. The caterpillar or grub is changed into the adult by a curious process known as histolysis.

ENTOMOLOGY—I



The lines, &c., show the natural sizes of the Larvæ, Pupæ, and Ova figured in the coloured plate

ENTOMOLOGY—I



INSECTS—LARVÆ, PUPÆ, AND OVA

During the pupal stage the greater part of the organization of the larva is destroyed and remodelled into the adult, which bursts out of the pupal shell the fully winged or perfect insect, its wings usually tightly folded up, but which soon expand and harden. There is no growth in the adult stage—a small fly does not become a large fly, a small bee a large bee, as some people think; the larval period only is the period of growth, the adult of reproduction.

There are two kinds of metamorphosis in insects, known as complete and incomplete metamorphosis. In the former we have the egg, the active feeding larva, the quiescent pupa (the period of metamorphosis), and the active sexual adult. In the second we have nominally the egg, the active, feeding, growing larva, an *active feeding* nymph or pupal stage, and then the adult. There is no complete change as in the former, but a gradual growth from the larval

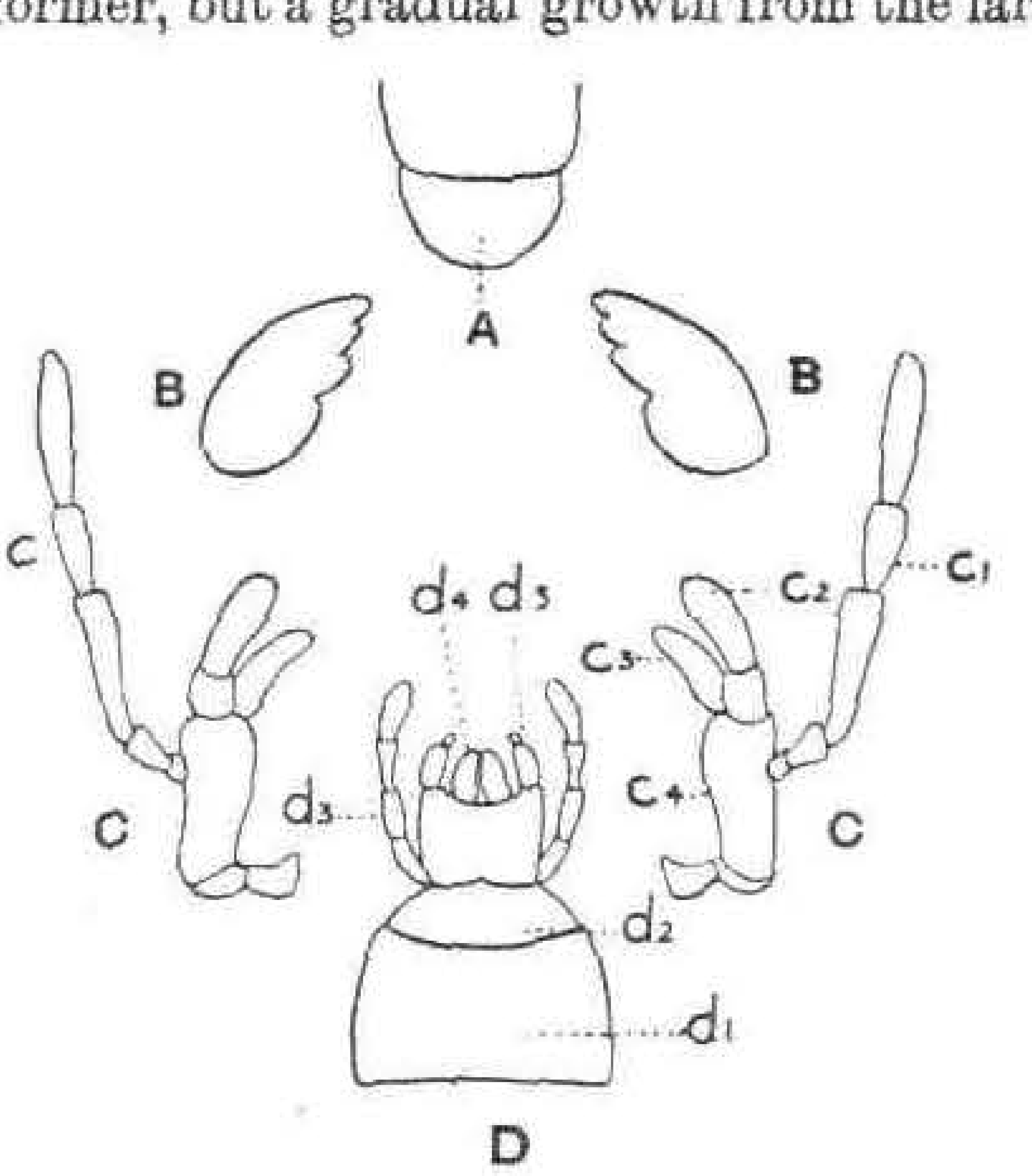


Fig. 3.—Biting Mouth Parts of an Insect

A, Upper lip. B, Mandibles. C, Maxillæ; c_1, palp; c_2, galea; c_3, lacinia; c_4, stipes. D, Lower lip; d_1, submentum; d_2, mentum; d_3, labial palp; d_4, glossa; d_5, paraglossa.

stage into the adult. The first we see in the change of a butterfly caterpillar into a butterfly, the second by the gradual growth of a young wingless grasshopper into the winged creature, wing buds appearing in the larva and gradually growing out. Some grasshoppers remain, as it were, in their larval condition permanently.

There are some primitive insects which undergo no metamorphosis at all (Aptera).

STRUCTURE OF A TYPICAL HEXAPOD.—A typical insect is divided into three parts—head, thorax, and abdomen. The head bears the mouth and organs of sense; the former is of three distinct types—(1) a biting mouth, (2) a piercing mouth, (3) a sucking mouth.

The first named is seen in beetles, caterpillars, &c., and may be taken as typical. It consists of the following parts: an upper lip, forming as if it were a roof; a lower lip the floor, and between are two pairs of jaws. The upper are hard and horny, and their cutting edges serrated. These are called mandibles, and are used for biting leafage, wood, &c. The second pair are softer, and are called maxillæ, or chewing jaws, and bear a jointed process on each, the maxillary palpi, organs of sense; the lower lips also bear two jointed sensory processes, the labial palpi.

In the piercing mouth, as seen in the mosquito, the oral parts are greatly elongated, the mandibles and maxillæ being in the form of

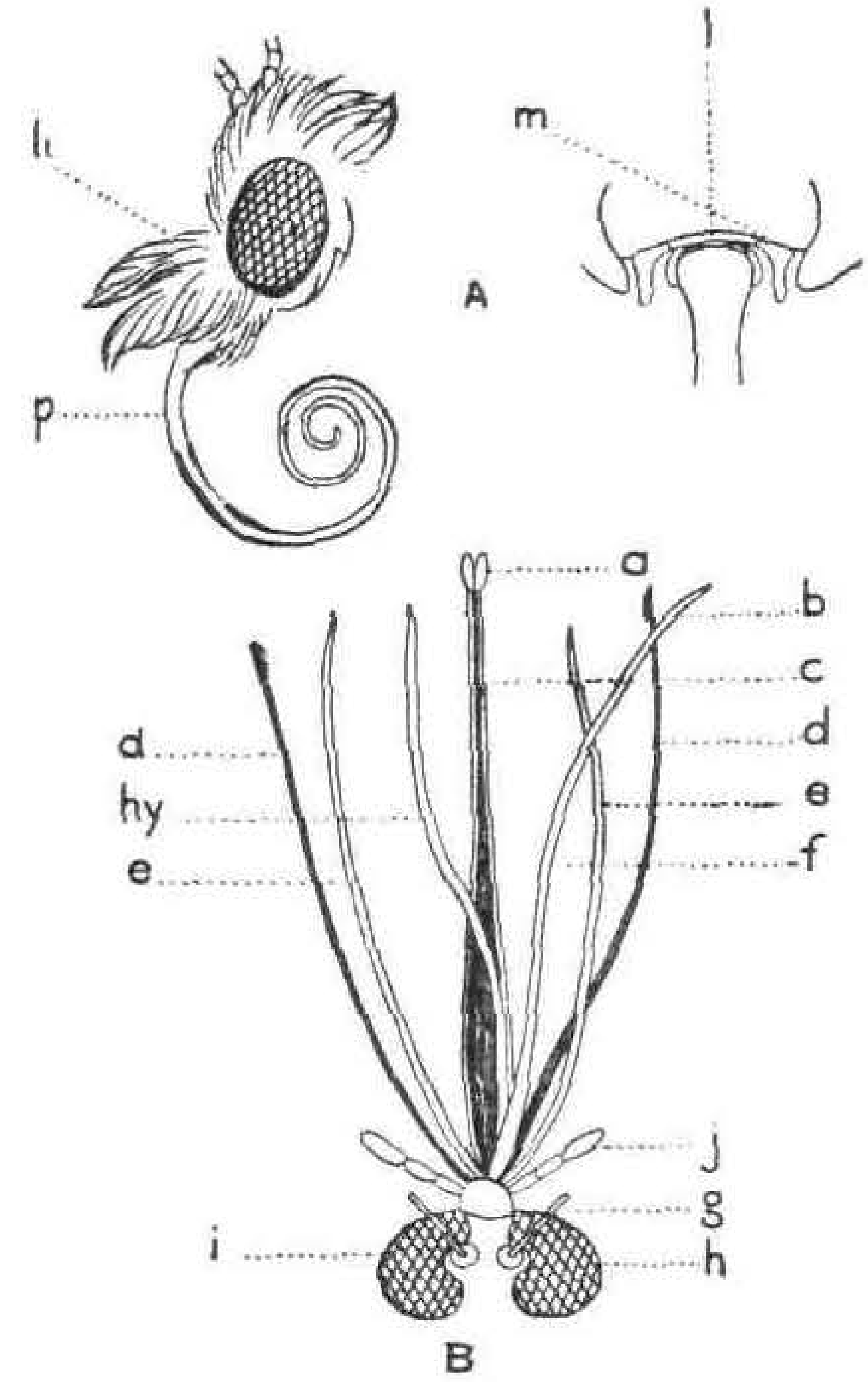


Fig. 4.

A, Sucking mouth of a Butterfly; *p*, proboscis; *l*, labium; l_1, labial palps; *m*, mandibles. B, Piercing mouth of a Mosquito; *a*, labial palps; *b*, labium epi-pharynx; *c*, labium; *d* and *e*, maxillæ; *f*, labrum; *g*, antennæ; *h* and *i*, ocelli; *hy*, hypo-pharynx; *j*, labial palp.

four needle-like lancets, protected by the tubular upper and lower lips.

In the sucking mouth, as seen in the butterfly, the upper lip and mandibles have nearly gone, the mouth being in the form of a long coiled proboscis made up of the maxillæ, and the lower lip is also much reduced; its palpi, however, are prominent as two feathery masses on each side of the head.

The eyes are of two kinds, compound or simple (ocelli), the former being paired and large, and made up of a number of separate parts, called facets, of hexagonal form; in male insects they usually take up most of the head, and meet in the middle line of the head; in the female they are separate.

The ocelli may be two or three in number, and are present as small spots on the summit of the head, but are not found in all insects. The other cephalic organs are the antennæ, jointed organs of sense, which are of very varied form, some being hairy (females), some densely plumose (males), or they may be threadlike, or pectinated, or lamellated.

The thorax bears the organs of locomotion, the six legs on the lower side, the wings above. This region is normally divided into three areas, the pro-, meso-, and metathorax, which vary in different insects. In some all are distinct, as in the locust; in others, mostly fused, as in the butterfly.

The legs are attached one pair to each division of the thorax. The insect leg is normally composed of nine pieces—the coxa (joining it to the body), the trochanter (a small segment next to it), the femur or thigh, the tibia or shank, and the tarsus or foot, composed of five segments; the latter may be much reduced (Scale Insects).

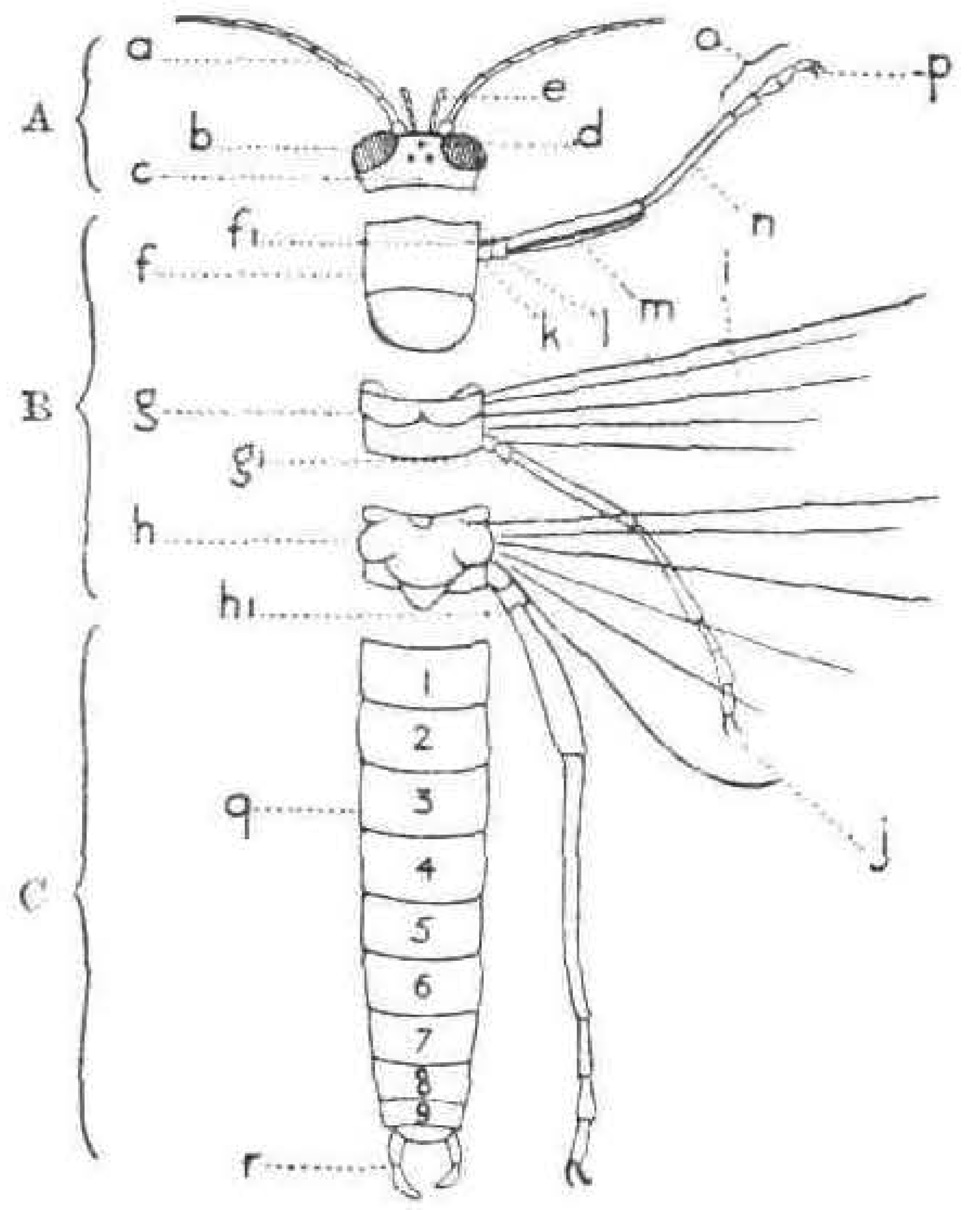


Fig. 5.—Structure of a Hexapod

A, Head: *a*, antennæ; *b*, compound eyes; *c*, occiput; *d*, ocelli; *e*, palpi. B, thorax: *f*, pronotum; f_1, prothoracic legs; *g*, mesonotum; g_1, mesonotal leg; *h*, metathorax; h_1, metathoracic leg; *i*, mesothoracic, and *j*, metathoracic, wings; *k*, coxa of leg; *l*, trochanter; *m*, femur; *n*, tibia: *o*, tarsus; *p*, ungues. C, abdomen; *q*, body segments; *r*, genitalia.

The wings are normally four in number, but may be reduced to two (Diptera) or none (Aptera). The first pair of wings are attached to the mid- or mesothorax, the second pair to the hind or metathorax. The wings are in the form of flat membranous expansions supported by ribs or veins (nervures), hollow tubes which contain air vessels, nerves, &c.

The body or abdomen is made up of fourteen segments or less, and bears no organs of locomotion. It may terminate in a sting, an egg-laying tube (ovipositor), or sawlike apparatus (Sawflies), or in the males in various male sexual external apparatus (genitalia).

ORDERS OF INSECTS.—The Hexapoda or Insects may be divided into smaller groups called orders as follows:—

A. With complete metamorphosis.

Order 1. *Coleoptera* (Beetles).—The front wings are hard and horny (elytra), and form shields beneath which the under soft membranous wings are folded. Mouth biting.

Order 2. *Hymenoptera* (Ants, Bees, and Wasps).—Four wings, all membranous; a distinct dark area on the outer border or costa (the stigma); cells of the wings few. Mouth biting and sucking, or biting only.

Order 3. *Lepidoptera* (Butterflies and Moths).—Four flat membranous wings covered more or less completely with flat scales. Mouth suctorial in adult; mandibulate in larva.

Order 4. *Diptera* (Flies).—Two wings only, attached to the mesothorax; the second pair reduced to club-shaped processes called balancers or halteres. Mouth suctorial or piercing. Mandibulate in larva.

B. Metamorphosis incomplete.

Order 5. *Hemiptera* (Bugs, Plantlice, &c.).—Mouth formed into a proboscis for suction and piercing. Wings four in number; all membranous (Homoptera or Plantlice, Scale Insects, &c.), or the front pair basally leathery and opaque (Heteroptera or Bugs).

Order 6. *Neuroptera* (Dragon Flies, Lace-wing Flies).—Four wings with a network of veins. Mouth biting.

Order 7. *Orthoptera* (Grasshoppers, &c.).—Four wings, front pair narrow and leathery, hind pair fan-shaped; veins of upper wings straight. Mouth biting.

Order 8. *Thysanoptera* (Thrips).—Four wings, very narrow and edged with fine hairs all around; small. Mouth weak, biting.

C. No metamorphosis.

Order 9. *Aptera* (Springtails, &c.).—No wings; either a springlike apparatus beneath or a tail-like process. Mouth weak, biting. Small.

DAMAGE CAUSED BY INSECTS.—The damage caused by insects and other Arthropods to man's crops and stock is very diverse. We must also bear in mind the loss they occasion amongst man's stores and buildings, and the evil effects they have upon man himself.

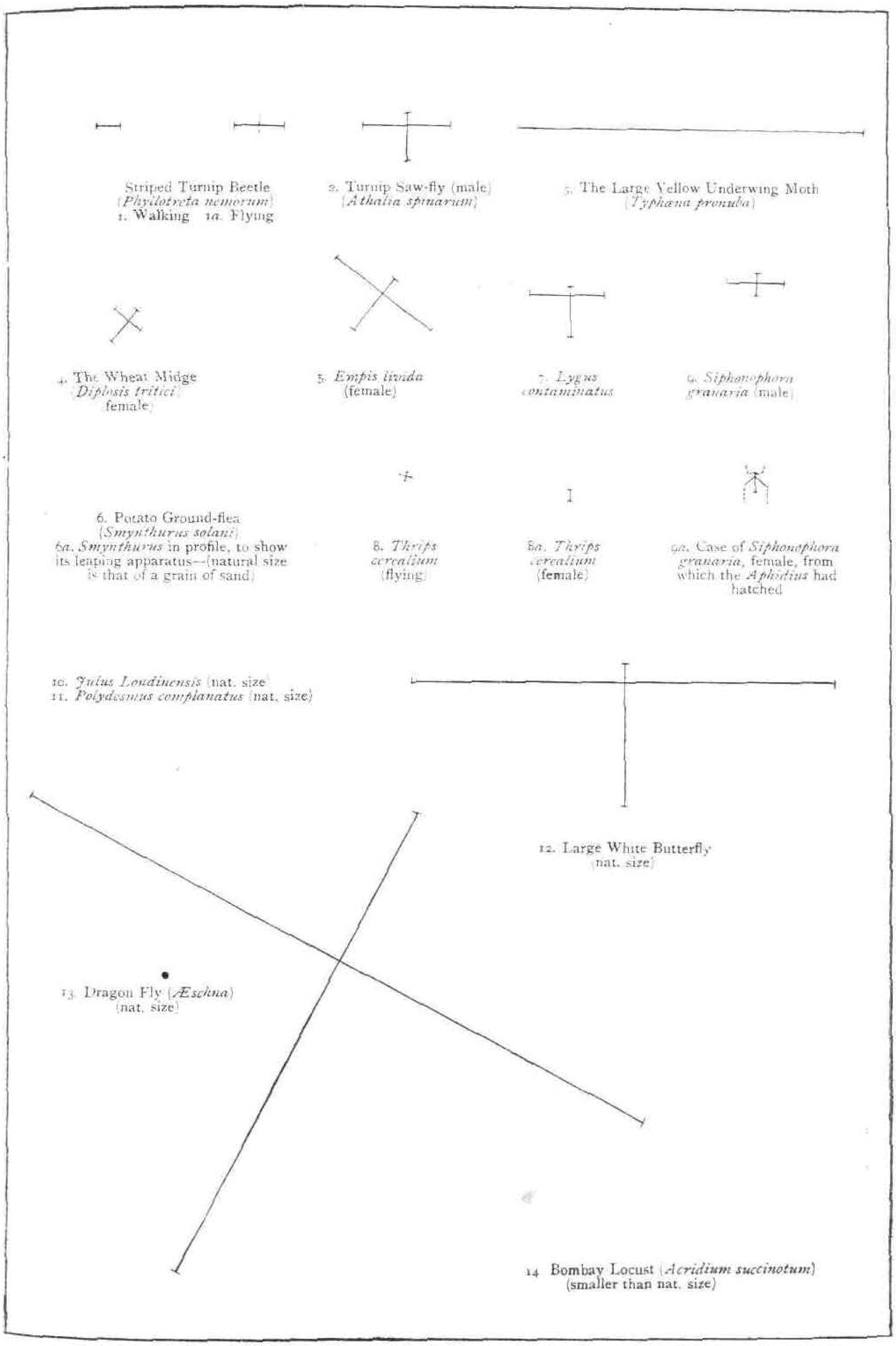
Insects may cause damage in all three stages—in the larval, pupal, and adult forms.

Only those which undergo an incomplete metamorphosis, such as the Aphis, can, however, do any harm in the pupal stage; the quiescent pupa of a moth or sawfly can do no harm. Generally speaking, it is the larval stage which is harmful, but the active pupæ of the Hemiptera and some Orthoptera also cause much loss amongst our crops and stores. The damage done by the adults is not very great, except where they act as bloodsuckers (and then their larval and pupal stages are innocuous), and where they carry disease from beast to beast and man to man, and amongst wood-boring, leaf-eating, and seed-feeding beetles.

Ticks, Red Spiders, Scab Mites are harmful in all three stages, there being no quiescent period. The first named act like the blood-sucking flies.

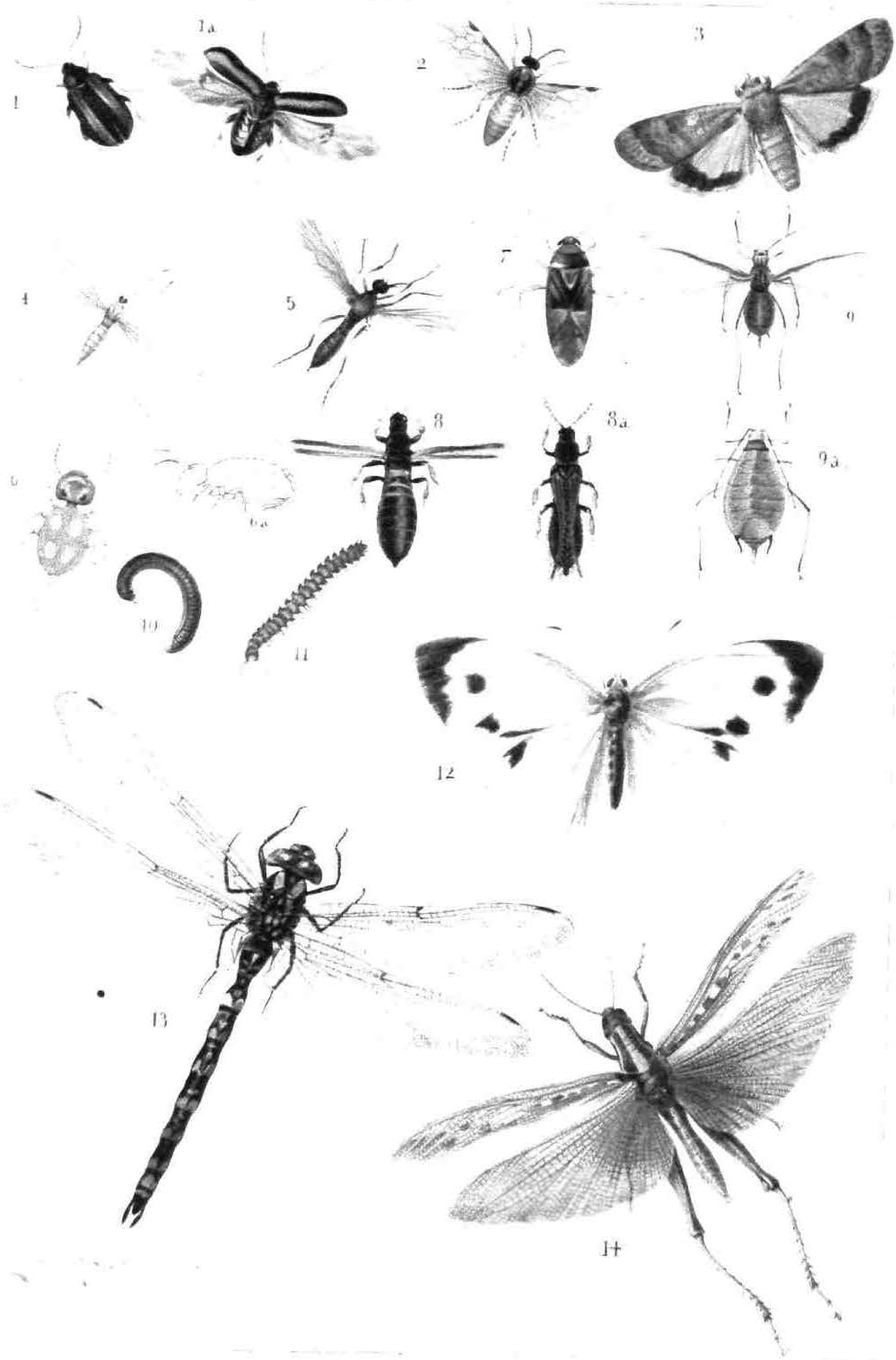
With regard to purely agricultural crops we find insects attacking all parts of the plant, the root, the stem, foliage, blossom, and seed.

The roots are attacked by various ground in-



The lines, &c., show the natural sizes of the Adult Insects figured in the coloured plate

ENTOMOLOGY—II



INSECTS—ADULTS

sects (Wireworms, Surface larvæ, Bibio larvæ, Chafers, Leather-jackets, &c.), which gnaw away at the surface of the roots, cut them in sunder or tunnel into them; others (Turnip Gall Weevil) produce galls or deformities on them and so stunt the growth. A few adult beetles even attack the plants below ground (Pigmy Mangold Beetle and Asparagus Beetle).

The stems are attacked by biting insects (as Surface larvæ), and are tunnelled into (Corn Sawfly), or may be damaged by sucking insects, such as aphides, and weakened so that they cannot remain erect, as is done by the Hessian Fly.

The foliage is attacked by many mandibulate insects and stripped (Mangold Beetles, Turnip Flea, Mustard Beetle, Cutworms), or mined into and blistered (Celery Fly, Mangold Fly), or it may be killed by the loss of the sap (Corn and Bean Aphides). Seedlings are killed by the Flea Beetles, which cut off the seedlings of turnips, swedes, and cabbage just below the seed leaves, or so riddle the cotyledons and young leaves that the plants die. Blossom is attacked often to a serious extent (Mustard Blossom Beetle and Mustard Beetle) by the larvæ, and to some extent by the adult; it is also damaged by thrips or Black Fly in the case of peas and beans, and in wheat and barley by midges (Wheat Midge, Barley Midge, &c.). Seed is ruined by larvæ, which mature in it (Bean and Pea Beetles, &c.).

In horticulture we get still more damage done, and of a more varied character. Fruit—both orchard and bush fruit—is often severely attacked. Here again we get enemies on root, trunk, foliage, blossom, and fruit. The roots of fruit trees are damaged when young by various larvæ (Leather-jackets, Chafer larvæ, Garden Swift Moth, Weevil larvæ), and even when well matured (Woolly Aphis and Currant Root Louse). Damage is done to the roots in two ways—(1) by biting insects, such as the Leather-jackets and Weevils, and (2) by sucking insects, such as Woolly Aphis, which cause galled swellings on the roots.

The stem and boughs may be infested by Scale Insects (Mussel Scale, Oyster-shell Bark Louse, &c.), and the bark is entered and damaged by bark-boring beetles (*Scolytus rugulosus*, &c.), and in a few cases the wood (sapwood) is tunnelled into by beetles and their larvæ (species of (*Xyleborus*), and the larvæ of moths (Goat Moth, Wood Leopard, &c.).

The foliage forms a feeding ground for hosts of caterpillars, which frequently strip the trees in spring and early summer, making them as bare as in midwinter (Winter Moth and Lackey Moth).

Blossom is attacked and prevented from developing (Apple Weevil, Green Pug Moth, and Bud Moth), and is killed just when it is setting (Apple Sucker).

The shoots of apple trees are cut off by beetles (Apple and Pear Twig Cutters), and are tunnelled into (Pith Moth) and so destroyed. Fruit is attacked by boring maggots (Codling Moth, Apple and Plum Fruit Sawflies, Fruit Flies), and maggots deform and destroy pears (Pear Midge).

Many leaf-eating caterpillars (Gold Tail Moth, Clouded Drab Moth, Winter Moth) also eat the fruit from outside and so spoil it, and in its ripe condition some, such as peaches and apricots, may be ruined by Hymenoptera (Ants and Wasps). Scale Insects also frequently disfigure and stunt the growth of fruit (Mussel Scale, San José Scale, &c.).

Similarly with garden plants, both culinary and ornamental, many insect pests are always at work. Roots and bulbs are attacked by larvæ (Wireworm, Leather-jackets, Narcissus Fly, Onion Maggot, Carrot Fly, &c.); the leaves eaten by larvæ (Tiger Moth, Gold Tail Moth, Cabbage Butterflies, &c.), curled and killed by aphides (Rose Aphis, Cabbage Aphis, &c.), and by sawflies (*Blennocampa pusilla*), and spotted and marbled and eventually destroyed by Leaf-hoppers (Rose Leaf-hopper, &c.).

Buds are attacked in garden plants by caterpillars (Rose Maggots), and blossoms eaten (Flat-bodied Carrot Moth, &c.), whilst the blossom itself is also spoiled by adult insects (Bumble Bees, Rose Chafer), and the stems tunnelled into (Rose Sawfly and Cabbage Fly).

Under glass we have vines attacked by Mealy Bugs and Phylloxera, peaches by Scale Insects (*Lecanium persicæ*), and various ornamental plants by many scale pests, aphis, and subterranean larvæ.

In the forest we get just the same, for roots of seedling trees are killed by chafers, ants, and various grubs; the trunks of trees tunnelled by larvæ (Goat Moth, Poplar and Willow Long-horn Beetles): the bark damaged (Scolytidæ, or Bark Beetle) and galled (Cynipidæ); shoots are tunnelled into and killed (Pine-bark Beetles and Pine-shoot Moth). Leaves are destroyed by numerous caterpillars (Oak Tortrix, &c.), and deformed by aphides (Larch Aphis, Spruce Gall Aphis) and gall flies (Oak Spangles and other leaf galls). Buds are also deformed by the latter (Oak Apples), and eaten by larvæ (Ash-bud Moth), or adults (Phyllobius Weevils).

The economic importance of insects in relation to stock is very great. First, insects are parasitic in animals. This we see in the Warble flies (Ox Bot, Horse Bot, Sheep Nasal Fly) living as parasites under the skin, in the alimentary canal, and in the head respectively. There are also many external parasites (Forest Fly, Sheep Maggot Fly, Fleas, Lice, and Biting Flies). The internal parasites weaken the health of the host, and so may kill it or predispose it to other diseases. The external parasites or biting insects also weaken the host by drawing away blood, and by irritation attending the bite. Still more they may carry disease, such as we see done by the Tsetse Flies, Gad flies, &c. (N'gana, Surra, &c.).

Farm stor and seeds are attacked by beetles and their larvæ (Corn Weevils, Meal Worms), and by caterpillars of moths (Mediterranean Flour Moth, Corn Moth), and buildings may even be destroyed by wood-boring beetles (Death-watch or Anobium, &c.).

Finally, man is attacked by biting insects, which carry to him definite diseases (mosquitoes and malaria, tsetse flies and sleeping sick-

ness), the insects either acting as hosts of the parasites, or they may act merely as carriers of disease germs (fleas and plague, gadflies and anthrax). Flies other than biting flies carry disease, and must be guarded against (house flies, milk and infantile diarrhœa, and house flies and enteric fever, &c.). Such are some of the varied ways in which hexapods are injurious.

Arachnoidea or Ticks, Scab Mites, &c.—The Arachnoidea are Ticks, Red Spiders, Scab Mites, Mange Mites, Gall Mites, as well as true spiders. These acari have eight legs in their adult condition, but only six in the larval stages. They can at once be told from a true insect by their body not being divided into three well-defined areas (see IXODIDÆ). Some live permanently on their host, others only go to their host to feed, and may moult once or twice on the ground.

The Ticks or Ixodidæ feed upon the blood of man, animals, birds, &c.; in doing this they not only cause severe irritation, but they weaken the host upon which they live. They play a still more important rôle, namely, as carriers of diseases, such as the red-water of cattle, the Rhodesian or East Coast fever, the heart-water of sheep, spirillosis in poultry, and human tick fever in Africa.

The Red Spiders or Trombidiidæ are plant pests, feeding upon the foliage, causing it to assume a marbled appearance, and later to shrivel up; some spin a web (Red Spiders of hops, *Tetranychus malvæ*, of the vine, *T. telarius*); others do not form webbing (Red Spider of gooseberry, *Bryobia nobilis*, &c., or of ivy, *B. pretiosa*). Like the former the larval stage is six-legged. They lay their eggs on the plants upon which they feed.

The Scab Mites or Sarcoptidæ are human, animal and bird parasites causing such diseases as scab in sheep (*Psoroptes communis*), scaly leg in poultry (*Sarcoptes lævis*), and human itch (*Sarcoptes scabiei*).

Mange Mites or Demodecidæ live in the hair follicles and cause bare or mangy patches (red mange in dogs, *Demodex folliculorum*).

Plants suffer also from the effects of gall-forming mites (*Euophyidæ*), which attack buds (Big Bud in Currants) and leaves (Pear Leaf Blister Mite, &c.).

SOME NOTABLE INSECT PESTS.—The chief agricultural pests, however, are Wireworm, Turnip Flea, Mustard Beetles, Surface larvæ, the Diamond-back Moth, and the Warble Fly.

We cannot estimate the annual damage done by the first named, but it must amount to some millions a year in this country, judging from the amount of wheat, roots, and other crops that are annually ruined by it.

With regard to Turnip Flea we can estimate the loss by a few figures: the loss in Devon in 1786 was £100,000; in 1881 in 22 English counties and 11 Scotch counties it amounted to over £500,000.

According to Miss Ormerod the annual loss from Warble Fly amounted to over £7,000,000 per annum, and since this estimate was made there has been but little decrease. The work even done by Surface larvæ is enormous; a market-garden farmer in Essex estimated his losses, direct and indirect, from injury to his *seedbeds* at over £100 in 1884.

One grower of rape seed lost over £1000 in one year from the Mustard Beetle, according to Miss Ormerod. It was estimated that the farmers in Aberdeenshire alone in 1892 lost £90,000 from the ravages of the Diamond-back Moth: and as the attack that year extended from Dover to the north of Scotland along the East Coast, the net loss must have been enormous.

Fruit growers often lose as great sums; for instance in 1810 no cider was made in Gloucestershire owing to the attack of the Woolly Aphis, and it was feared that the industry must have been altogether abandoned. Other great losses have taken place in apples by the Codling Moth; for instance, in 1877, in many Kent orchards, 20 to 30 per cent of the apples fell from this cause, and many others were rendered valueless. In 1907 one orchardist in Kent estimated the damage done by Lackey Moth caterpillars in his plantations at some hundreds of pounds.

The Apple Sucker has been known (1906) to destroy quite 70 per cent of the apple blossom in Worcestershire. One cannot put in pounds, shillings, and pence the actual loss, but each year it must amount to some hundreds of thousands of pounds alone in fruit from insect pests.

The Hop Aphis is another insect which often entails enormous loss and expenditure in keeping it in check. In the serious blight in 1882 not a hop was picked in many important hop-growing parishes, and it was estimated that the whole produce of the hop land in England, 65,619 ac. in 1882, did not exceed 114,832 cwt., or an average of $1\frac{3}{4}$ cwt. per acre. The average yield in England is 7 cwt. per acre, or a total in 1882 of 459,333 cwt., which at £7, 7*s*. per cwt. (the average price for twenty years previous to 1882) would represent a total of £3,376,177. Besides the growers' loss, labour also lost in that year as much as £225,000.

LIST OF THE CHIEF INSECT PESTS.—Amongst the more important insect and mite pests referred to in this Cyclopædia are the following:—To corn crops: *Agriotes lineatus* (Striped Click Beetle), *Zabrus gibbus* (Corn Ground Beetle), *Crioceris melanocera* (Oat Crioceris), **Agrotis exclamationis* (Heart-and-Dart Moth), *Cecidomyia destructor* (Hessian Fly), *Diplosis tritici* (Wheat Midge), *Oscinis frit* (Frit Fly), *Chlorops tæniopus* (Gout Fly), *Hylemyia coarctata* (Wheat Bulb Fly), *Cephus pygmæus* (Corn Sawfly), *Siphonophora avenæ* (Corn Aphis), *Thrips crealium* (Corn Thrips).

Amongst grass pests are: *Tipula oleracea* (Daddy-long-legs), *Melolontha vulgaris* (Cockchafer), *Agriotes lineatus* (Wireworm), and *Charæas graminis* (Antler Moth).

The chief enemies of pulse are: *Sitones lineata* (Pea and Bean Weevil), *Bruchus pisi* and *B. rufimanus* (Seed Beetles), *Phytomyza pisi* (Pea-leaf Miner), *Thrips pisivora* (Pea Thrips), *Cecidomyia pisi* (Pea Midge), *Grapholitha pisana* (Pea Maggot), *Aphis rumicis* (Bean Aphis).

The root-crop pests are: *Phyllotreta nemorum* (Turnip Flea), *Haltica oleracea* (Cabbage Flea),

Steropus madidus (Wurzel Ground Beetle), *Silpha atrata* and *S. opaca* (Carrion Beetles), *Atomaria linearis* (Pigmy Mangold Beetle), *Agrotis exclamationis* (Heart-and-Dart Moth), *Plusia gamma* (Silvery Y Moth), *Plutella maculipennis* (Diamond-back Moth), *Ceutorhynchus sulcicollis* (Turnip Gall Weevil), *C. assimilis* (Turnip and Mustard Seed Weevil), *Meligethes æneus* (Blossom Beetle), *Athalia spinarum* (Turnip Sawfly), *Aphis raphæ* (Turnip Aphis).

Vegetable pests include: *Psila rosæ* (Carrot Fly), *Acidia heraclei* (Celery Fly), *Crioceris asparagi* (Asparagus Beetle), *Agriotes lineatus* (Wireworm), *Pieris brassicæ*, *P. raphæ*, and *P. napi* (White Butterflies), *Typhæna pronuba* (Yellow Under-wing), *Mamestra brassicæ* (Cabbage Moth), *Aphis brassicæ* (Cabbage Aphis).

Flowers are attacked by: *Hylemyia nigrescens* (Carnation Maggot), *Merodon equestris* (Bulb Fly), *Eriocampa rosæ* (Rose Slugworm), *Blennocampa pusilla* (Rose Leaf-rolling Sawfly), *Emphytus cinctus* (Rose Emphytus), *Megachile centuncularis* (Leaf-cutting Bee), *Arctia caja* (Tiger Moth), *Orygia antiqua* (Vapourer Moth), *Spilonota roborana* (Brown Rose Grub), *Siphonophora dirhoda*, *S. rosæ* (Rose Aphides), *Philænus spumarius* (Cuckoo Spit Insect).

The hop pests are: *Phorodon humili* (Hop Aphis), *Plectrocellis concinna* (Hop Flea), *Hepialis humuli* (Ghost Moth), *Agriotes* spp. (Wireworm), *Calocoris fulvomaculatus* (Needle-nosed Hop Bug), *Tetranychus malvæ* (Red Spider), *Blanjulus guttulatus* (Small Snake Millipede).

The following are the more important fruit pests:—

1. To Apple: *Cheimatobia brumata* (Winter Moth), *Hybernia defoliaria* (Mottled Umber Moth), *Anisopteryx æscularia* (March Moth), *Clissiocampa neustria* (Lackey Moth), *Ægeria myopæformis* (Apple Clearwing), *Zeuzera æsculi* (Wood Leopard), *Carpocapsa pomonella* (Codling Moth), *Blastodacna vinolentella* (Pith Moth), *Lyonetia clerckella* (Apple-leaf Miner), *Hyponomeuta malinella* (Little Ermine Moth), *Hoplocampa testudinea* (Apple Sawfly), *Aphis pomi*, *A. sorbi*, and *A. fitchii* (Apple Aphides), *Mytilaspis* (*Lepidosaphes*) *ulmi* (Mussel Scale), *Schizoneura lanigera* (Woolly Aphis), *Psylla mali* (Apple Sucker).

2. To Cherry: *Diloba cæruleocephala* (Figure-of-8 Moth), *Argyresthia conjugella* (Cherry Fruit Moth), *Semasia woeberiana* (Cherry Stem Borer), *Myzus cerasi* (Cherry Black Fly), *Ragoletis cerasi* (Cherry Fruit Fly).

3. To Currant and Gooseberry: *Ægeria tipuliformis* (Currant Clearwing), *Abraxas grossulariata* (Magpie Moth), *Incurvaria capitella* (Currant Shoot and Fruit Moth), *Lecanium persicæ* var. *sarothamni* (Currant and Gooseberry Brown Scale), *Pulvinaria vitis* var. *ribesii* (White Woolly Currant Scale), *Rhopalosiphum ribis* (Currant Blister Aphis), *Myzus ribesiæ* (Currant Leaf-curl Aphis), *Eriophyes ribis* (Currant Gall Mite).

4. To Damson and Plums: *Scolytus rugulosus* (Bark Beetle), *Xyleborus dispar* (Shot Hole Borer), *Diloba cæruleocephala* (Figure-of-8 Moth), *Aspidiotus ostreæformis* (Oyster-shell Bark Louse), *Aphis pruni* (Leaf-curling Plum Aphis), *Hyalopterus pruni* (Mealy Plum Aphis), *Chlorita viridula*, *Typhlocyba quercus* (Leaf-hoppers).

5. To Pear: *Diplosis pyrivora* (Pear Midge), *Cemiostoma scitella* (Pear-leaf Blister Moth), *Orygia antiqua* (Vapourer Moth), *Eriophyes pyri* (Pear-leaf Blister Mite), *Schizoneura lanigera* (Woolly Aphis).

6. To Raspberry: *Lampronia rubiella* (Raspberry Shoot Borer), *Emphytus cinctus* (Raspberry Stem Sawfly), *Siphonophora rubi* (Raspberry Aphis), *Otiorhynchus picipes* (Raspberry Weevil), *Byturus tomentosus* (Raspberry Beetle).

7. To Strawberry: *Pterostichus vulgaris*, *Steropus madidus*, *Calathus cisteloides*, *Harpalus ruficornis* (Strawberry Ground Beetles), *Melolontha vulgaris* (Cockchafer), *Galerucella tenella* (Strawberry-leaf Beetle), *Peronea comariana* (Strawberry-leaf Button Moth), *Hepialus lupulinus* (Garden Swift Moth), *Aphelenchus fragariæ* (Eelworm disease).

8. To Nuts: *Balaninus nucus* (Nut Weevil), *Cræcus septemtrionalis* (Nut Sawfly), *Phyllobius maculicornis* and *P. viridis* (Leaf Weevils), *Pterocallis juglandis* (Walnut-leaf Louse), *Carpocapsa splendana* (Walnut and Chestnut Maggot), *Eriophyes avellanæ* (Nut Gall Mite).

9. To Vines: *Otiorhynchus sulcatus* (Vine Weevil), *Dactylopius* (*Coccus*) *longispinosus* and *D. adonidum* (Mealy Bugs), *Tetranychus telarius* (Red Spider).

10. To Peach, Nectarine: *Lecanium Persicæ* (Brown Scale), *Aphis amygdali* (Peach Aphis).

The following are the chief pests in forest trees:—

1. Hardwoods: *Cossus ligniperda* (Goat Moth), *Cerura vinula* (Puss Moth), *Cheimatobia brumata* (Winter Moth), *Hybernia defoliaria* (Mottled Umber Moth), *Orygia antiqua* (Vapourer Moth), *Tortrix viridana* (Green Oak Tortrix), *Prays curtiscella* (Ash-bud Moth), *Scolytus destructor* (Elm-bark Beetle), *Saperda populnea* (Poplar Longhorn), *Aromia moschata* (Willow Longhorn), *Phratora vitellinæ* (Willow Beetle), *Orchestes fagi* (Beech Weevil), *Attelabus cuculionoides* (Sweet-chestnut Box Beetle), *Cryptorhynchus lapathi* (Willow Weevil), *Cynipidæ* (Gall Flies), *Schizoneura ulmi* (Elm Woolly Aphis), *Eriophyes rudis* (Witches'-broom Gall).

2. On Conifers: *Hylobius abietis* (Pine Weevil), *Pissodes pini* and *P. notatus* (Spotted Pine Weevils), *Hylesinus piniperda* (Pine Beetle), *Hylastes palliatus*, *Pityogenes bidentatus*, *Fidonia piniaria* (Bordered White Moth), *Retinia buoliana* (Pine Shoot Moth), *R. turionana* (Pine-bud Moth), *R. resinella* (Pine Resin Gall Moth), *Argyresthia lævigatella* (Larch Shoot Moth), *Coleophora laricella* (Larch Case Bearer), *Lophyrus pini* (Pine Sawfly), *Nematus erichsoni* (Large Larch Sawfly), *Sirex gigas* (Giant Wood Wasp), *S. juvencus* (Steel-blue Wood Wasp), *Megastigmus spermotrophus* (Douglas Pine Seed Fly), *Chermes laricis* Larch Aphis), *Chermes abietis* (Spruce Gall Aphis), *Chermes pini* (Weymouth Pine Aphis).

The chief animal pests are:—

1. On Cattle: *Hypoderma bovis* and *H. linearis* (Ox Warble Flies), *Tabanus bovinus* and *T. bromius* (Gadflies), *Trichodectes scalaris* and *Hæmatopynus eurysternus* (Lice).

2. On Sheep: *Œstrus ovis* (Sheep Nasal Fly),

Lucilia sericata (Sheep Maggot), *Trichodectes sphærocephalus* (Red Louse), *Melophagus ovinus* (the Ked), *Psoroptes communis* var. *ovis* (Sheep Scab), *Ixodes ricinus* (Sheep Tick).

3. To Horses: *Hippobosca equina* (Forest Fly), *Hæmatopinus macrocephalus* (Horse Louse), *Gastrophilus equi* (Horse Bot).

4. Of Pigs: *Hæmatopinus urius* (Pig Louse).

5. Of Dogs: *Hæmatopinus piliferus* and *Trichodectes latus* (Dog Lice), *Pulex canis* (Dog Flea), *Ixodes ricinus* (Tick), *Demodex folliculorum* (Mange Mite).

6. Of Cats: *Pulex felis* (Cat Flea), *Sarcoptes minor* var. *cati* (Cat Mange).

7. Of Poultry: *Pulex avium* (Bird Flea), *Menopon biseriatum*, *Goniodes dissimilis*, *Lipeurus variabilis* (Fowl Lice), *Sarcoptes lævis* (Scaly Leg Mite), *Sarcoptes mustans* (Depluming Scabies), *Dermanyssus avium* (Red Bird Mite).

The chief enemies of man's stores and provisions, &c., are: *Ephestia kuhniella* (Mediterranean Flour Moth), *Sitotroga cerealla* (Corn Moth), *Calandra granaria* and *C. oryzæ* (Corn and Rice Weevils), *Asopia farnialis* (Meal Moths), *Tenebrio molitor* (Meal Worms), *Anobium domesticum*, *Xestobium tessellatum* (Furniture Beetles), *Blatta orientalis* (Cockroach), *Lepisma saccharina* (Silver Fish).

Man's enemies include: *Anopheles* and *Culex* (Mosquitoes), *Pulex irritans* (Human Flea), *Pediculus capitis*, *P. inguinalis*, *P. vestimenti* (Head, Body, and Clothes Lice); *Cimex lectularius* (Bed Bug), *Musca domestica* (House Fly), *Calliphora vomitoria* (the Blow Fly), *Leptus autumnalis* (Harvest Bug), and *Sarcoptes scabiei* (Itch Mite).

The Importation of Insect and other Pests.—Our knowledge of fruit pests and the enemies of stock enable us to see how easily they are imported from country to country. The Codling Moth, the Slugworm, the Mussel Scale are instances of fruit pests which have been distributed artificially all over the world. Still more recently we have seen how the San José Scale has spread from China all over America and to many other places, and is causing endless loss. This artificial distribution is by means of nursery stock, fruit and ornamental plants. Great quantities of Codling maggots are imported to this country every year in apples from America, Madeira, and Portugal, helping to swell the native race living here. Scale insects are always liable to be introduced on nursery stock and ornamental plants, such as has taken place here with the Japanese Fruit Scale, numerous hothouse Scale Insects. Fruit Flies (*Ceratitis*, *Dacus*, *Ragoletis*) are very easily taken from country to country. We find the latter frequently in cherries imported to Britain from the Continent. Animal parasites are still more easily introduced (Keds, Ticks, Warble Flies, Lice). Nothing but port inspection and drastic legislation can stop this.

Beneficial Insects.—Although there are great numbers of insects which are injurious, there are also some which are beneficial. In a state of nature these latter keep the balance of life; but so altered are the conditions under cultivation of the land that they cease to be more than of interest, being incapable of coping with the insect pests favoured by cultivation and the growing together of great masses of one food plant.

Amongst these beneficial insects we find two kinds—parasitic and predaceous. The former live within other insects or their eggs, the latter feed upon them. The chief parasitic insects are known as Ichneumon Flies, Chalcid Flies, and Tachina Flies; the first two are Hymenoptera, the last Diptera.

The Ichneumon and Chalcid Flies lay their eggs in the bodies of the larvæ and in the eggs of other insects, and so destroy them before they reach maturity; but the hosts when larvæ are not usually killed until they are nearly mature and have done the damage to our crops; but when eggs are parasitized, as in the Hessian Fly, the maggots are prevented from appearing, and so damage is checked. Many Scale Insects suffer from these Chalcididæ, yet they continue to cause endless harm.

The Tachina Flies are mainly found as parasites in caterpillars, and hatch out of the pupæ (*Telemorpha marmorata* and Brown Tail Moth). Lady-bird Beetles (Coccinellidæ) are the most beneficial predaceous insects, for they feed in their adult and larval (or 'nigger') stages on all kinds of Plantlice and on Scale Insects. Unfortunately they usually only commence to occur in large numbers when the aphides swarm and the damage is done (Hop Fly and Lady-bird).

Other predaceous beetles are some of the Ground Beetles (Carabidæ), which feed in both larval and adult stages on ground and arboreal larvæ.

The leechlike larvæ of the Hover Flies (Syrphidæ) also feed upon Plantlice, and also the voracious huge-jawed larvæ of the Aphis Lions or Lace-wing Flies (Chrysopidæ). Numerous Hymenoptera provision their nests with weevils and flies (Odynerus, Pemphedon, &c.).

Certain Americans lay great stress upon these natural enemies. The Fulted Scale attacking oranges having been checked in its destructive work by importing an Australia Lady-bird (*Vedalia cardinalis*), gave great impetus to the study of this subject, and some success appears to have attended the breeding of the natural enemies of the Sugar Cane Leaf-hopper in Hawaii.

In most cases enthusiasm has led to useless spending of money in this respect (supposed enemies of Fruit Flies in South America, &c.). Farmers and fruit growers are not likely to receive any benefit from this treatment in this country or in our Colonies. Under natural conditions parasitic and predaceous insects undoubtedly help to restore the balance of nature when upset, and to some extent keep it in equilibrium, but under the altered conditions on cultivated land they lose their power.

Remedial and Preventive Measures used in Checking Insect and other Pests, &c.—Various remedies are now adopted to combat insect and other pests. These consist of special cultured treatment, trapping, and the employment of insecticides and insectifuges and acaricides. Insecticides are substances and mixtures

used to kill insects. They may be either used as dusts or powders, or as fluids in the form of 'washes', or so-called 'spray' fluids. They are of two classes—those which poison insects and those which act as corrosives. Insecticides were used many years ago, but we do not know when plants were first syringed to kill insects.

Early in the history of plant disease, paints and washes were in general use. These were applied by means of brushes or rags, a method still used in glasshouses. In 1763, aphides were killed by tobacco and water. In 1794 we find unslaked lime and salt being used to kill scale insects by Perley. Hellebore was commonly recommended in 1842 for 'worms' on gooseberry bushes. It was not until the Evesham fruit growers in 1890 took up the matter of spraying for caterpillar that much was done in Britain, although the use of arsenical sprays had been previously recognized in America. By degrees this spraying of fruit trees has steadily increased, stimulated largely by Cousins and others in 1896, and by Pickering in recent years.

The substances now used for poisons are arsenical washes (see ARSENICAL COMPOUNDS), hellebore, and pyrethrum. For corrosive washes, quassia and soft soap, caustic alkali washes, and various emulsions of paraffin oils. Vegetal washes used long ago, such as tobacco wash, are now being revived. Many patent mixtures are being thrown on the market, some of which are good, others of little value; few do all they are said to do.

Considerable advance has recently been made in machines for spreading the insecticides. These are of four classes: knapsack sprayers carried on the back; more powerful pumps in tanks or barrels, worked by hand; still heavier ones drawn by horse-power, and lastly, steam or gas-engine sprayers.

The object generally is to send the insecticide out in as fine a mist as possible, so that every part of the tree or plant is wetted by the insecticide. This is done by using considerable pressure, driving the fluid out with air through special nozzles so that the particles are finely divided. This is not always necessary nor advisable, for some washes are best applied thickly (lime and salt, &c.). Other machines are made for distributing powdered insecticides and acaricides (sulphurators).

Another method of treating insect pests is by fumigation. This is mainly done under glass and to nursery stock. The substances used are hydrocyanic acid gas and tobacco fumes, and to some extent pyrethrum (see arts. on FUMIGATION and HYDROCYANIC ACID GAS).

The destruction of insects in the ground is not fully understood; the greatest success is attained by injecting disulphide of carbon into the soil. Some patent preparations are sold which claim to destroy all ground insects, but in practice they are not found to do so; cultural methods are of more benefit.

Acaricides are substances used to kill Red Spiders, Mites, Ticks, &c. Sulphur and creosotes are largely used for this purpose, also paraffin and arsenic. For plant parasites they are used in the form of sprays, fluids, or as fumigants in the case of sulphur. For the destruction of acari, &c., on animals in the form of dips, see SHEEP DIPPING.

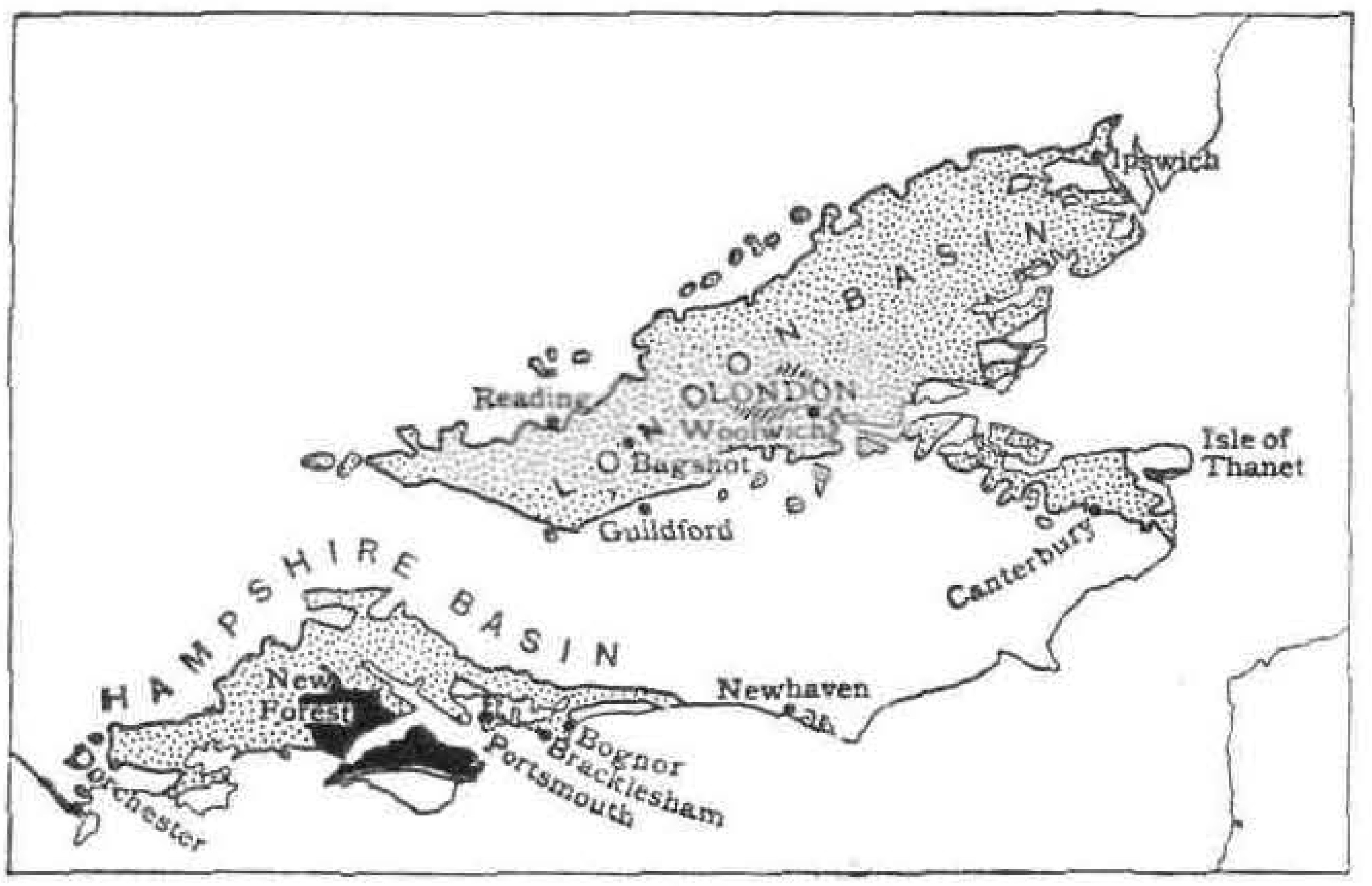
INSECT LEGISLATION.—Under the Destructive Insects and Pests Act of 1877, as enlarged in 1907, the Board of Agriculture are empowered to deal with certain outbreaks in a drastic way.

The insects at present scheduled are the Colorado Beetle (*Doryphora decemlineata*), the Fruit Fly (*Ceratitis capitata*), the Large Larch Sawfly (*Nematus erichsoni*), the Japanese Fruit Scale (*Diaspis amygdali*), and the San José Scale (*Aspidiotus perniciosus*). The first has appeared once in England (at Tilbury in 1901), and was stamped out by the energies of the Board; the Japanese Fruit Scale has once appeared, but most of the infested trees were burned, and it is not found now in Britain. The Ceratitis is not likely to live here except under glass, and the Large Larch Sawfly is a fairly widely distributed native insect, and is of little importance. The San José Scale (*Aspidiotus perniciosus*) is not likely to live in this country. There is power, however, to add to the list, and there are many important pests to schedule, such as the Cherry Fruit Fly (*Rhagoletis cerasi*), so abundantly imported in late French cherries, and a type of insect capable of flourishing in this country. This Act was brought in on account of the scare created in connection with the Colorado Beetle. The wisdom of it was seen during the outbreak of this serious potato pest in 1901. [F. V. T.]

Enzyme is the name given to some chemical substances, the products of living cells, which are capable of producing certain fermentative changes. An enzyme does not in itself constitute a living entity, and it is incapable by itself of any further increase or reproduction. For this reason enzymes are distinguished from the large class of ferments described as micro-organisms, in which each individual represents a complete and living organism capable of reproducing its kind. The latter class for convenience are classed as organized, and the former as unorganized ferments. Enzymes are found widely distributed in both the vegetable and animal world, and to their action must be attributed many of the vital changes necessary for growth. The presence of a small quantity of enzyme is capable of producing a large chemical change. The active element in the digestive juices secreted by the animal body, the chemical changes accompanying the germination of seeds, indeed metabolic changes in general are largely the work of enzyme action. The character of enzyme action may be likened to that of a catalytic agent. Thus, taking the action of the digestive juices, the enzyme does not appear to possess the power in itself of producing chemical change in the organic substances in the food, but it appear to render such substances more unstable, and thus facilitate or accelerate the action of hydrolytic and other agents present in the juice. Enzymes are soluble in water and glycerine, and are precipitated from solution by absolute alcohol without decreasing their active properties. They are stable at a moderate temperature, and can be dried without harm. Different enzymes

act best at different temperatures. There are several classes of enzymes, namely, those acting upon (1) carbohydrates, (2) proteids, and (3) glucosides, oils, &c. [R. A. B.]

Eocene System.—This system of strata *is far better developed in the north of France* than in our islands. The English Eocene beds, however, give considerable variety of surface conditions. The Chalk had been upheaved and denuded for some time before the Cainozoic sea invaded our area, and abundant flint pebbles, worn from it, characterize some of the early horizons. The types of strata differ somewhat in the London area from those in Hampshire, the southern series representing more continuously marine conditions of deposition. The beds are classified as follows:—



Sketch Map of Eocene System

Hampshire Basin	London Basin
5. Barton Beds.	Upper Bagshot Sands.
4. Bracklesham Beds.	Bracklesham (or Middle Bagshot) Beds.
3. Lower Bagshot Beds.	Lower Bagshot Sands.
2. Bognor (or London) Clay.	London Clay.
1. Plastic Clay.	Lower London Tertiaries (including Oldhaven Beds, Woolwich and Reading Beds, and Thanet Sand).

The Hampshire Basin is an area between the Chalk of Dorset, Wiltshire, and Sussex, on the one hand, and that which forms a backbone to the Isle of Wight on the other. The London Basin is another triangular area, its apex lying on the back of the Chalk near Marlborough, and its base running from Ipswich to Deal. The lowest beds thus appear in both basins as a marginal band, with outlying patches resting on the Chalk. The Plastic Clay is a stiff brown clay, with occasional pebble beds, as near Romsey; in the London area, however, the bottom of the Eocene beds is formed of Thanet Sand, a glauconitic yellowish sand, resting on an eroded surface of chalk. Over this the Woolwich and Reading Beds are mainly stiff clays in the west or Reading area, but include layers of shells and a loose conglomerate of flint pebbles in the east or Woolwich portion. Here the very pebbly Oldhaven Beds occur at the top, producing ridges covered with heath and fir trees, as may be seen eastward of Blackheath. Overlapping the other beds, they form outliers resting on the Surrey Chalk, such as the pebbly and sandy Worms Heath above *Limpsfield*, on the edge of the North Downs.

The London Clay that follows in both basins is a strong bluish clay, containing sulphide and carbonate of iron, and weathering brown in its upper portion. It is largely used for making bricks, and is fortunately overlain in the London district by drift gravels, which give the house sites a good drainage (see H. B. Woodward, The Soils of London, Geol. Survey).

The superficial deposits, including the Chalky Boulder Clay, promote successful tillage in many places where the London Clay alone would provide a very unsatisfactory soil. Market gardening is carried on extensively in the level land west of London. On the north, the London Clay forms a somewhat hummocky country, with good pasture, and this clay underlies nearly the whole surface of the London Basin.

The beds that follow appear mainly as outliers, left after the prolonged denudation that has laid bare such an extent of London Clay. The Lower Bagshot Sands thus occur on the crest of Hampstead Heath, and form a small area of heath and firwood high above the smoke of London. On the south-west, far broader areas of horizontal Lower Bagshot Sand, with Middle and Upper Bagshot Beds above, form a wooded country from Esher almost to Odiham. The Middle beds are more clayey, but have little influence on the generally poor quality of the land. While Bagshot Heath lies mainly on the Middle Bagshot (or Bracklesham) Beds, Chobham Ridges, rising as a north-and-south plateau 9 miles long, is formed by an outlier of the Upper Bagshots. The dense fir woods near Aldershot fully rival those on the Lower Greensand hills to the south. Were it not, then, for Post-Pliocene loams and other mixed deposits, the London Basin would offer few attractions to the tillage farmer. Even some of the gravelly drifts have to be avoided on account of the rapidity with which water drains away in them. The importance of the great alluvial infillings in the valleys, and of the drift-deposits capping many of the hills, is admirably seen in the Drift-maps of the British Geological Survey, as for instance in Sheet 268.

In the Hampshire Basin, the London or Bognor Clay appears marginally above the band of Plastic Clay, and the greater part of the area of Eocene rocks is covered by the Lower Bagshot, Bracklesham, and Barton Beds. Uncultivated heathy commons are frequent on these strata round about the Oligocene beds in the New Forest. This type of country spreads into

Dorsetshire, and prevails round Bournemouth and through the lowland of Poole harbour, as well as on the more hilly ground beyond Wareham. The Barton Beds consist of the Barton Clay, overlain by the Barton sand. The latter is cut into by the Avon and Lymington rivers descending from the New Forest, and also forms a broad band in the Forest area, succeeded as we go outwards from the centre by the Barton Clay. None of these lands on the higher Eocene strata can be considered as agriculturally important.

In western Scotland and northern Ireland, the Eocene period is represented by great outpourings of basaltic lavas (see art. BASALT), with thin plant-beds included between them.

[G. A. J. C.]

EOCENE SOILS.—The stiffer of the Eocene deposits of the London and Hampshire Basins produce tenacious clays, impervious to water, and very difficult to till. Formerly, when wheat was dear, a considerable area of this land was under cultivation, and a rotation was practised which provided for the raising of wheat, beans, and clover, with a fallow every fourth or fifth year for cleansing purposes; now the ordinary crop raised is grass for hay to supply the London market. On the other hand, much of the London and Hampshire Basins are occupied by soils of the very opposite description, derived from the sandy and gravelly deposits, and a great variety of soils of an intermediate type are to be met with where these formations lie close against outcrops of London or Plastic Clay. In the river valleys, as of the Thames and Avon, very fertile free-working loams appear, making excellent barley land.

The Thanet Sands, at the base of the system in the London Basin, yield a sandy loam, which, like all sandy loams, is responsive to good treatment, and is capable of producing all the ordinary farm crops, including hops, sainfoin, and lucerne. These soils are found in the Isle of Thanet, and in certain circumscribed areas in Kent and Surrey. The soils of the Isle of Thanet itself are remarkable for the good quality of the malting barley they produce.

Where the Woolwich and Reading Beds come to the surface, the soils show a great variety, resulting from the distribution and frequent repetition of sandy and clayey strata in the formation. Loams are the prevailing soils, and these are largely under cultivation.

Where the clay beds are unmodified by admixture with the sandy strata, as often happens, a most refractory soil is the result. This soil, if worked in a wet condition, forms into brick-like lumps, which on drying cannot be reduced to a proper condition of tilth by any ordinary implement of tillage; it is in consequence mostly allowed to remain in grass. As might be expected, artificial manures are of little or no use on these clays. Their physical condition may be improved by chalking with the material ready to hand in the Upper Chalk, an application of lime, or the ploughing in of farmyard manure.

London Clay soils are strong, wet, impervious, and tenacious clays of a brownish, though in some places of a greyish or yellowish colour. The soil particles are very finely divided; a mechanical analysis shows that the great bulk of the 'fine earth' (in this case, material below 3 mm. diameter) is finer than ·05 mm. ($\frac{1}{500}$ in.), while about 56 per cent of it is finer than ·01 mm. diameter. In dry weather these clays shrink and crack in a vertical direction to a depth of 3 or 4 ft. Through these fissures excessive evaporation takes place in very dry seasons, but when the rain comes they rapidly close up, leaving again an impervious surface. This land is much too strong for the growth of either turnips or barley, and since wheat has gone so much out of cultivation, consequent on the fall in prices, the bulk of the formation is left under grass. The surface of the London Clay in Middlesex is mainly devoted to meadow farming, and two-thirds of its area are under hay for the supply of the London markets.

As on the Plastic Clay, artificial manures are not very effective on the soils of this series, but dressings of lime in any form, and applications of farmyard manure, give good results. The London Clay has no springs and yields no water except in the basement beds. The forest trees which flourish on the London Clay are the elm, the oak, and the ash.

Above, and resting on the London Clay, the Bracklesham and Bagshot Sands form light sandy or gravelly soils which are agriculturally very poor, and which are often occupied by heaths and moors. The 'Greywethers' or sandstone boulders which prevail over many areas of the Chalk, and which furnish the farmers with building material, gateposts, and road metal, are residues from Eocene strata which have been mainly removed by denudation. [T. H.]

Ephedrus plagiator.—The female of this minute fly lays its eggs in the female aphides of the wheat and other plants. The little maggots hatch and destroy the aphis, from the black horny skin of which the little parasites emerge by forcing out a door behind. They are black and shining, with two slender antennæ; the body is brown, with a short-pointed ovipositor; the legs are ochreous; four hinder thighs and tarsi, pitchy. [J. C.]

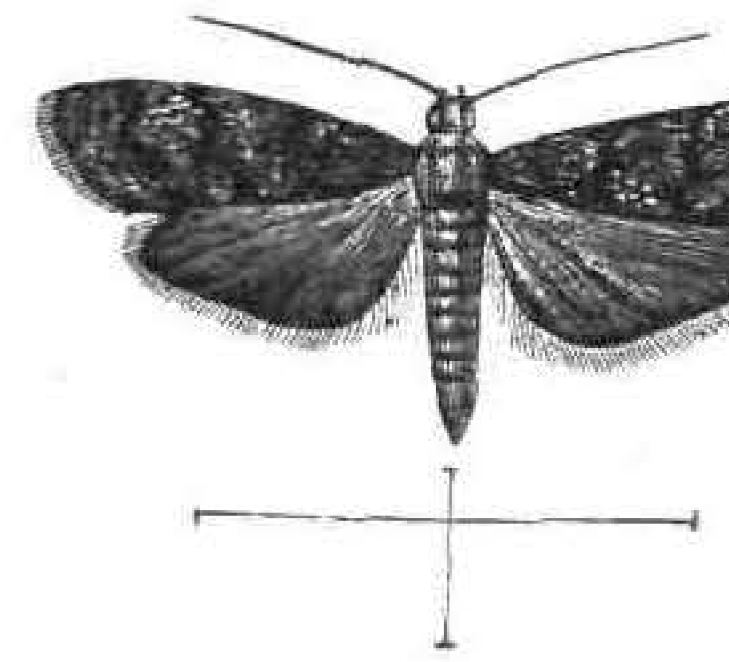
Ephemerals. See AGE OF PLANTS.

Ephestia kuhniella (the Mediterranean Flour Moth).—This moth is one of the worst scourges of the flour mill. It is now found over most of Europe, has gradually spread over Britain, and made its way to America. It was comparatively unknown until the moth was discovered in a mill in Germany in 1877. In 1886 it appeared in England, in 1889 in Canada, and in 1892 in the United States. It seems, however, to have been known in Europe in 1840. It also occurs in South America and in Australia.

The moth has a wing expanse of a little less than an inch; the front wings are dull leaden-grey to pale-grey, with transverse dark markings, hind wings dusky-white with darkened border. The caterpillar is whitish and hairy, and the pupa reddish-brown. The moth lays her eggs on the flour, meal, &c., both when stored and in what collects in the machinery. The larvæ form cylindrical silken tubes, and

this matting of webbing clogs up the machinery, silks, &c., in the mills, as well as spoiling the flour. The larvæ will also feed in the same way in corn and bran. The life-cycle lasts about two months in this country, but is more rapid in warm climates. In warm mills there may be several generations during the year. So great is its destructive power that mills frequently have to be shut down owing to blocking of machinery. The pest is spread in sacks in which the meal or flour is stored and moved.

Treatment consists of seeing that all sacks, &c., are well cleansed by being placed in scalding water. When a mill is badly infested, it must be either fumigated with carbon bisulphide or hydrocyanic acid gas, or steam may be turned



Mediterranean Flour Moth (*Ephestia kuhniella*)

from the engines over the walls, machinery, &c., followed by a thorough cleaning out and whitewashing. Flour can only be cleaned by heat, as fumigation is of no value. It is a costly and troublesome pest to deal with, and must be coped with strenuously. [F. V. T.]

Epidemic Diseases, diseases that become prevalent occasionally owing to special causes, but are not endemic or permanently associated with a locality. They include a large class of maladies in all parts of the world; and no matter whether the climate be temperate, torrid, or frigid, epidemic diseases are periodically at work. From time immemorial, epidemical invasions of disease have occurred amongst men and animals, frequently with most disastrous results. Necessarily every disease has one or more centres of origin, from which it is liable to spread north, south, east, and west. Murrain affords a typical example of an epidemical disease, and many agriculturists will remember the great invasion (1864) of Great Britain by the cattle plague. Such diseases as measles, scarlatina, smallpox, bubonic plague, &c., in man frequently assume the epidemic character. Such diseases in the case of animals are often called *Epizootic*. Epidemical diseases are communicated through the agency of winds, birds, rodents, the clothing of man and animals, through water pollution, and a variety of other channels and agencies. See EPIZOOTIC DISEASES. [F. T. B.]

Epidermopteæ, a group of cutaneous mites, very minute in size, which live on the surface of the skin of birds, at the bottom of the plumage among the down. They frequently multiply to excess, and cause intense pityriasis. They are all colourless acari, some almost transparent. The two commonest species are *Epidermoptes bilobatus* (Rivolta) and *Rivoltasia bifurcata* (Rivolta); both occur on poultry throughout Europe. They produce dirty-yellowish scales on the skin, particularly at the base of the feathers, at other times a whitish crust. Various species occur on wild birds. They do not produce any serious affection in poultry. [F. V. T.]

Epilepsy.—Epileptic or cataleptic fits are not infrequent in calves, pigs, and dogs. Their exact nature is not well understood, but they appear to depend upon digestive derangements, teething difficulties, and parasitism, the attacks commonly, but not in all instances, ceasing when these causes have been removed. Young pigs are frequently seized on coming to the trough. They raise their heads and fall over backwards. The symptoms common to all animals affected are insensibility, rolling of the eyes, clenching of the teeth, frothing at the mouth, and violent muscular contractions. The heart can often be heard to beat loudly, while respiration is almost suspended. The excitement is followed by a comatose condition, from which the animal awakes apparently well again. Fits connected with the generative organs are described under the heading of ECLAMPSIA. During the fit, the animal should be prevented from biting its tongue or otherwise injuring itself while unconscious. A purgative should be administered, the teeth examined, and worm medicines given if required. [H. L.]

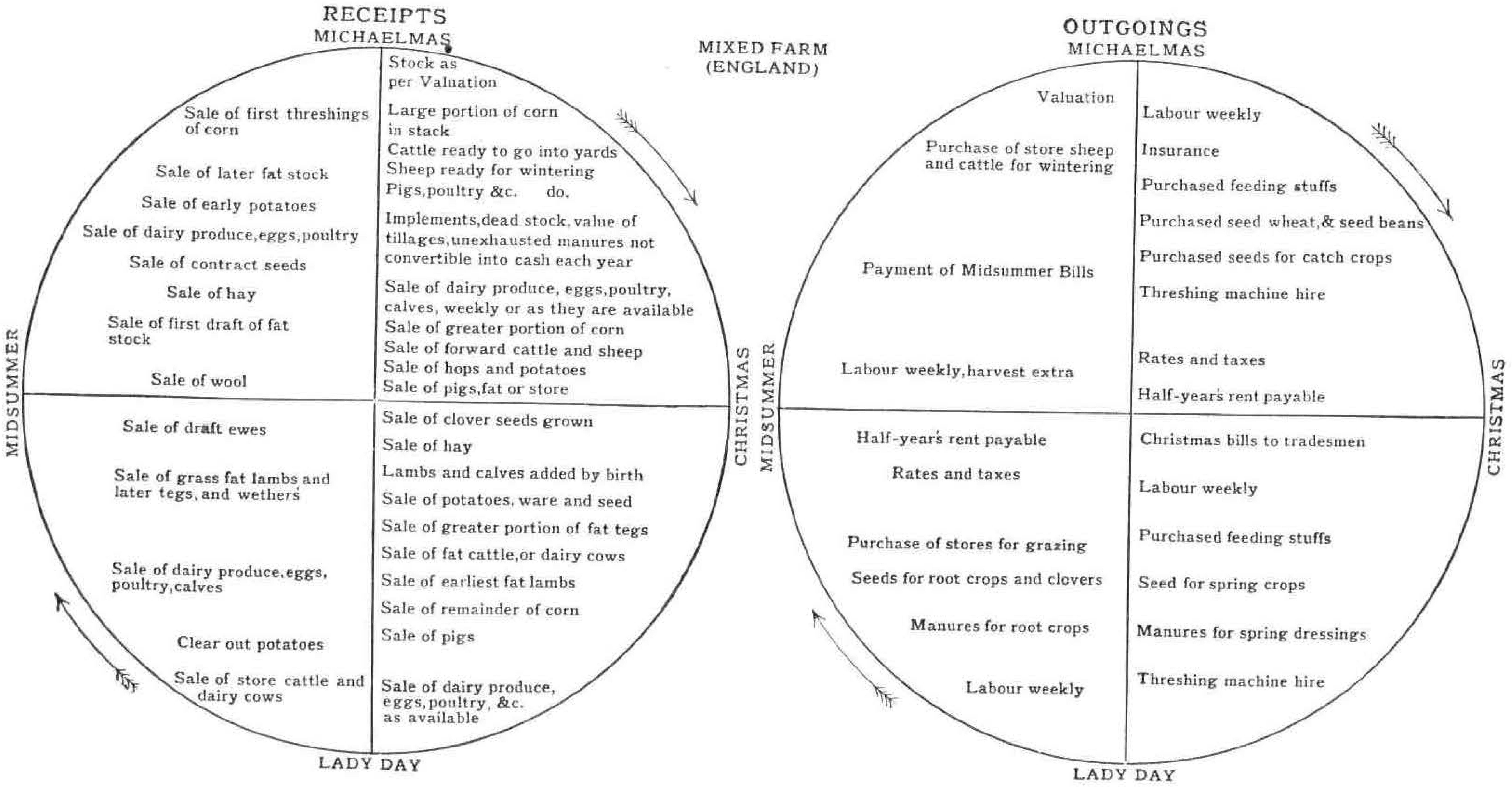
Epilobium, a large genus of herbs or undershrubs belonging to the order Onagraceæ. They are distributed over the temperate regions of the world, ten species being natives of the British Islands. The British species are popularly known as willow herbs, one of the best of them being *E. hirsutum*, which is often abundant in wet places in this country; but when once established in the garden, they spread so rapidly by means of subterranean stolons that they are difficult to eradicate. They are all best accommodated by the side of a pond or lake, or in the wild garden. The French Willow (*E. angustifolium*) is equally handsome, growing to a height of about 6 ft., and producing in July spicate racemes of bright-red flowers. See also WILLOW HERB. [W. W.]

Epimedium, a genus of hardy herbaceous perennials related to the Barberries. They are excellent plants for the rockery; they flower early in the year; the flowers are followed by elegant compound bright-green leaves, and these again in autumn assume a rich coppery-red colour. The best of them are *E. alpinum*, which is naturalized here and there in Britain; *E. macranthum*, a Japanese plant with white flowers; *E. Peralderianum*, yellow flowers, the leaves bright-green with reddish veins; and *E. rubrum*, the crimson and yellow flowers being large for the genus. [W. W.]

Epizootic Diseases.—The term 'epizootic' is nearly synonymous with 'epidemic', but is specially applied to diseases affecting animals other than man. An epizootic disease is one that spreads from its centre or centres of origin into other districts, continuing to spread amongst animals until the virus has exhausted itself, or its ravages have been curtailed by controlling measures. Foot-and-mouth disease, cattle plague,

CHART OF SALES AND PURCHASES

SHOWING SEASONS WHEN CASH MAY BE REQUIRED AND OBTAINED



The above shows the circulation of money on a farm starting with (or whilst running from) Michaelmas, and position of live and dead stock as regards their condition for sale or purchase.

contagious lung fever, swine plague, tick fever, all afford examples of epizootic diseases. An enzootic malady frequently becomes an epizootic, *i.e.* a complaint at work in one district may, through the ordinary channels of communication, spread to other districts. See ENDEMIC, EPIDEMIC, and INFECTIOUS DISEASES.

[F. T. B.]

Equipment.—Equipment in the necessary provision of means to carry on a farm is of two kinds, that provided by the landlord, and that provided by the tenant. Broadly speaking, the landlord provides all except that which the tenant can take away or receive compensation for when leaving the farm. This applies to Great Britain but not to Ireland, as, since the passing of the 1880 Act, the landlord there has no interest in the land beyond that which represents the prairie or unimproved and undeveloped value. The Irish landlord has not to provide housing, barns, cattle sheds, or other of the many permanent buildings, fences, roads, &c., which are expected in Great Britain. Whatever of these the Irish landlord had provided were taken from him and given to the tenant on the day in which the Act was brought into force; moreover, this tenant right, as it was called, was handed over to the tenant as a present, for which he paid nothing, and for which the landlord received nothing. At present what the landlord has paid for in Great Britain remains his; and it is expected of him that he should make his land attractive and convenient for the tenant to hold, by building a substantial farmhouse, and a homestead suitable for the system of farming which is to be adopted. Further, he is expected to provide suitable cottages for workmen, should there not be housing conveniently near. As this is not the place to go far into details showing the cost of developing the land from a prairie condition to that suited to the requirements of modern farming, reference is advised to Mr. Albert Pell's paper on the 'Making of the Land of England', which appeared in vol. xxiii, second series, of the Journal of the Royal Agricultural Society.

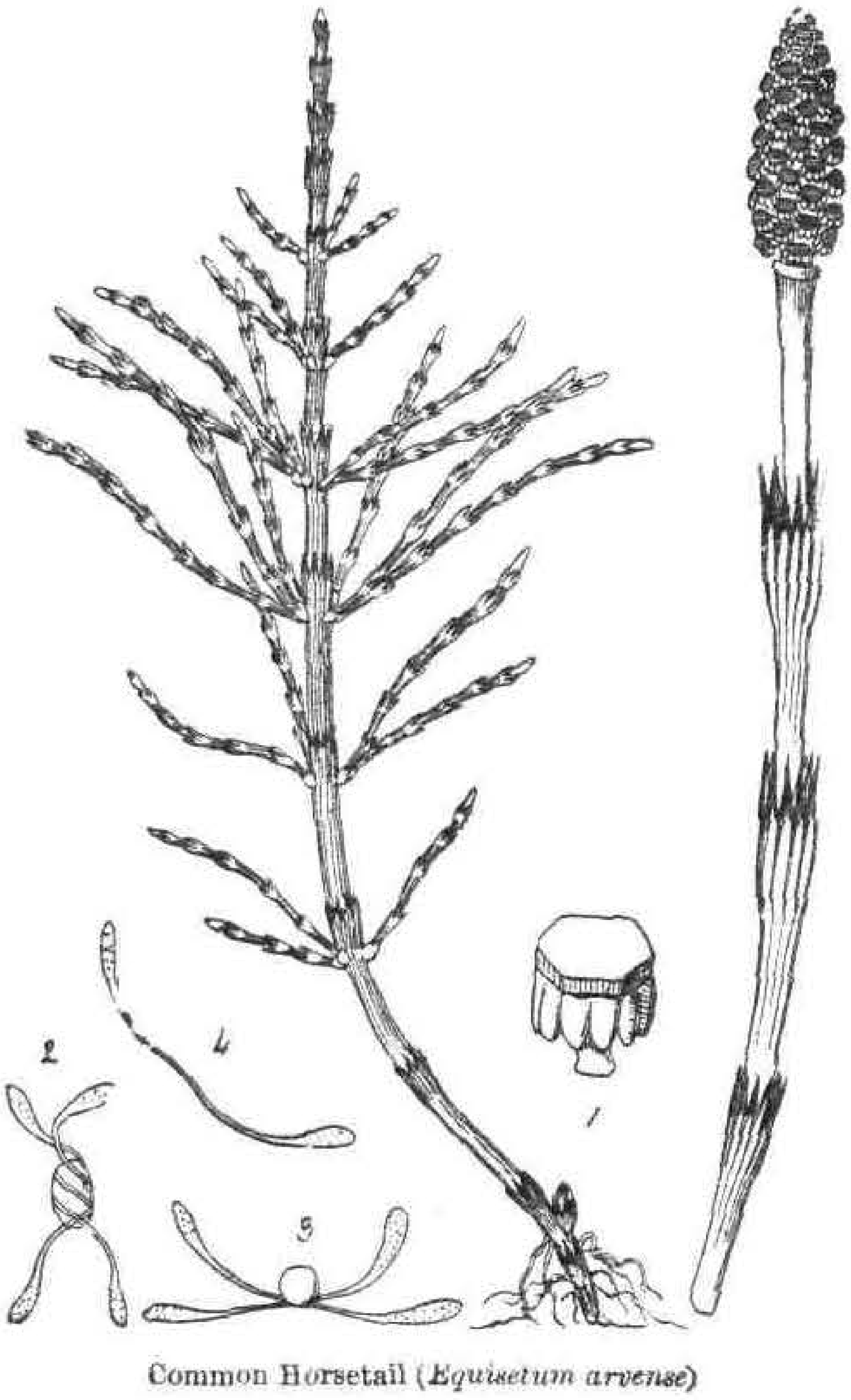
The British tenant's equipment comprises the live and dead stock; but he must possess capital to work the land and provide means to pay rent, rates and taxes, labour, and to purchase the tenant right, and pay for the unexhausted improvements; he is supposed to live out of the profits of his business, so must make provision for living before he makes a profit; and during his first year, and from year to year, he must employ his capital so that he will have it available as he requires it. The accompanying chart shows how he may expect his money to circulate, and the occasions when he may have to meet calls upon it. The order in which the items are given are roughly chronological, but seasons and circumstances alter cases.

On an arable or mixed farm the equipment may be regarded as fullest just when the corn harvest is got in, and the sheep and cattle for wintering are on the farm; though often the former has to provide for the latter. The farmer who arranges that he has a full head of stock, and his hay and corn harvest in hand, would generally find that at some other seasons he has a considerable idle balance; a more skilled man would keep his stock in circulation so as to avoid this, and work equally well on a smaller capital; but the nature of the farm would greatly control this. It used to be regarded that £10 per acre was necessary for the proper working of a farm worked on a mixed system; but having in view the smaller cost of feedingstuffs, manures, the great saving in the use of modern machinery, the lower price of stock, lower rent, and other features, equal effect may be secured from a capital of £1 to £1, 10*s.* per acre. But men moving with the times are not satisfied with this, and by more rapid output of meat by the free use of feedingstuffs and manures, and by more rapid cropping of the land through the aid of catch crops, can still employ the £10 per acre profitably; and it is these who, with skill in their work, make farming most profitable now.

The British farmer during recent years has met conditions in respect to manual labour which have never prevailed before. He has had difficulty in finding capable workmen, and the men work fewer hours, and with less energy. Apart from its national aspect, this has not been an unmixed disadvantage. The British farmer was listless as to the advantages of mechanical aids, in fact was often strongly prejudiced against change. He now finds that his machinery equipment stands second to nothing in respect to the successful carrying on of his farm; for not only does it affect his manual labour bill, but his horse and horse-corn account. The chilled breast-digging plough calls for only two-thirds the horse labour of the older types; moreover, less work is required to reduce land so ploughed to a suitable seedbed. Further, the modern sickle-tine cultivator produces a seedbed without nearly so much prejudicial horse trampling, and at much less expense. The same cultivator can be the most easily steered horse hoe, and the most effective; moreover, it is a far more expeditious land ridger or moulder than the old double-breasted plough, doing three times the work, and it may be fitted with a broadcast seedbox for corn sowing; rendering it unnecessary to add those other implements and machines to the equipment of the farm. The modern corn drill can be bought for half the price of its predecessors. The binder can now be bought for £23, and does its work so cleanly that the horse rake is unnecessary, and effects the work for far less than manual labour. The mowing machine at £12 has practically caused the disappearance of the scythe, while the introduction of the swath turner and the hay collector has rendered unnecessary the hay tedder and horse rake in the hayfield. Other illustrations could be given showing how the number of implements on the farm can be reduced, so that the machine bill need not be increased beyond that of a generation ago, yet giving far greater efficiency and rendering unnecessary the employment of a large number of hands. The cost of the production of crops has materially lessened, relatively better crops are grown, and the equipment has been reduced in number, and enhanced in efficiency

where skill has been employed in the choice of machines. The full influence of the agricultural motor, capable of doing the greater part of the work of the farm more cheaply than by present power, has not been realized; but owing to its cheapness and versatility it is destined to work profound changes. [W. J. M.]

Equisetum arvense (Field, Corn, or Common Horsetail) is a flowerless plant often occurring as a weed on undrained land, of which it is a certain sign. The underground stem creeps extensively and branches extensively, sending



Common Horsetail (*Equisetum arvense*)

1, Scale with sporangia. 2, 3, Spores with filaments. 4, Filament detached

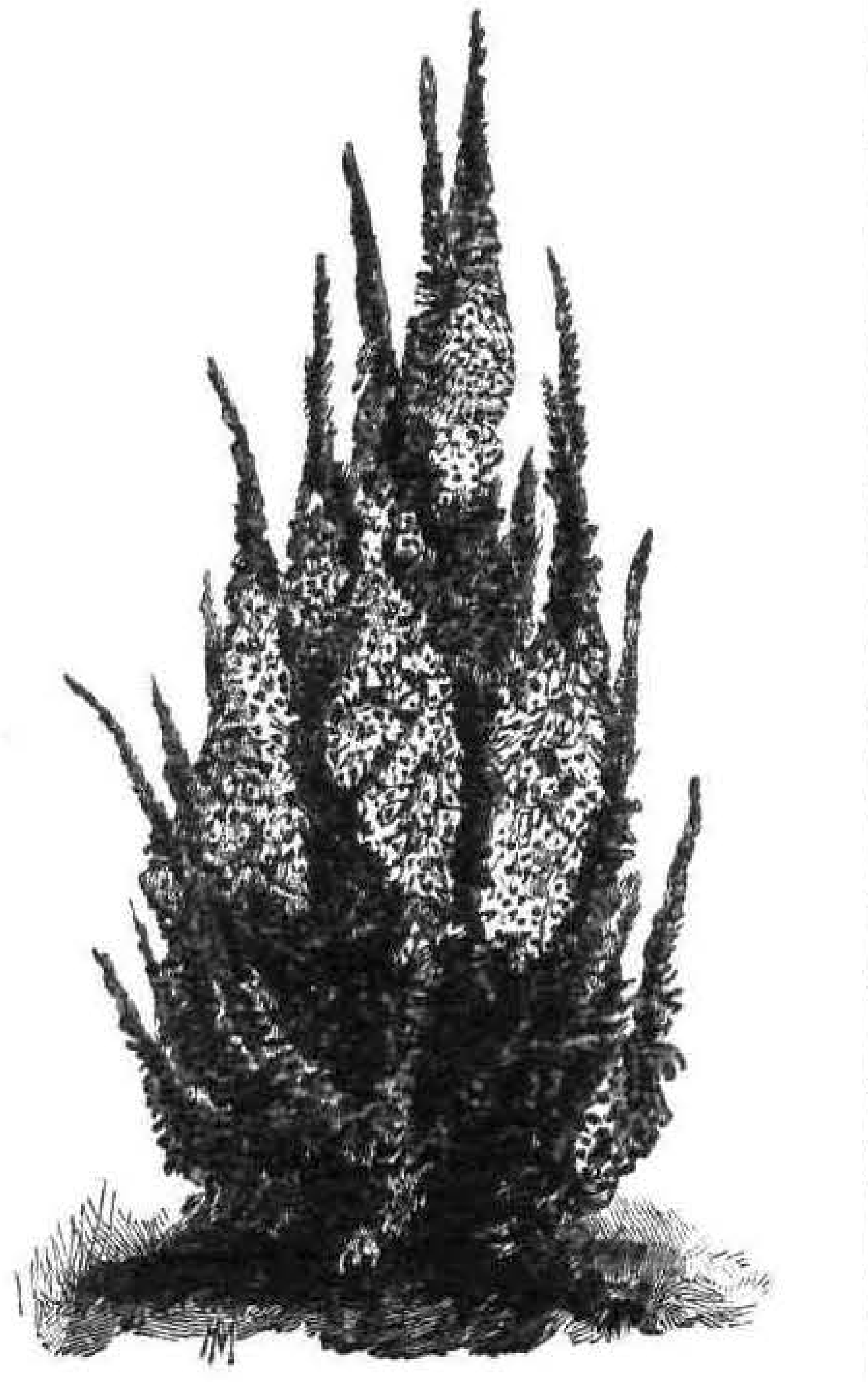
up short air shoots, 8 in. high, early in April. This air shoot is a cylinder, furrowed externally and hollow internally, bearing widely spaced, toothed sheaths, three-fourths of an inch long. It terminates in a cone-shaped body composed of flat-headed scales. When this cone is shaken on the hand, abundance of green powder pours out, and each grain of this powder is a spore which has to do with the reproduction of new Horsetail plants—indeed the whole shoot is nothing but a spore-making and spore-disseminating machine, a purely reproductive apparatus, hence its name *fertile shoot.* When the spores are shed the fertile shoots, now of no further use, die down, and a second set of shoots springs forth. These, however, are quite unlike their predecessors; they are conspicuous and deep-green, 1½ ft. high, and bear branches arranged in rings, to the number of ten per ring. These green shoots have nothing whatever to do with reproduction,—their sole object is to manufacture food—and they are named accordingly *barren shoots.* The food manufactured by these barren shoots is partly consumed in maintaining the growth of the extensive underground establishment, and partly stored up in the underground parts for renewing the successive crops of barren and fertile shoots next year.

The great and efficient remedy for Horsetail is drainage; as soon as excess of water is removed from the soil the Horsetail dwindles and begins to die away. Plough, harrow, and grubber may of course help to uproot the underground parts, and any uprooted portions must be removed with extreme care, for if but one tiny cutting of the underground stem is left behind, that suffices to renew the plant. The weed may also be kept in check and starved out by early and repeated removal of the green shoots. Also the formation of new plants by spore reproduction may be prevented if we remove the first crop of fertile shoots in early spring as soon as they show above ground. [A. N. M'A.]

Eremurus, a genus of stately bulbous plants found in northern India and Persia, and related to the Asphodel. They have a fleshy perennial rootstock, from which is developed annually a hyacinth-like cluster of strap-shaped leaves about 2 ft. long, and stout, erect, tall scapes bearing spicate racemes of white, pink, mauve, or yellow flowers. Some of the species, when happily situated, develop spikes as much as 10 ft. in height, which are at their best in mid-June. They are excellent plants to associate with loose-growing shrubs, and are most effective when the spikes stand above a groundwork of such plants as dwarf acers, or even loosely planted rambler roses. The bushes afford some protection to the young leaves, which push through the soil early in the year. They all prefer a rich, deep loamy soil, and they dislike disturbance of the roots. When planting, the crowns should be set at least 6 in. below the surface. Slugs greedily eat the leaves and young flower spikes, and they must be kept off during April and May, when the plants are most likely to be attacked. The best species are *E. Aitchisoni, E. aurantiacus, E. Bungei, E. himalaicus,* and *E. robustus.* Hybrids and varieties of these are now in cultivation. [W. W.]

Ergot, a diseased condition of the grain of rye and other cereals, and of cultivated grasses (*e.g.* Rye Grass, Foxtail, Timothy, &c.); also observed on nearly every species of wild grass. The life-history is described and illustrated under Rye. Ergot grains are common in grass seeds, but care is required to distinguish them from droppings (mice, rats, weevils, &c.). The grains found on any grass are generally slightly larger than a healthy grain and are black; the larger size enables them to be cleaned out fairly completely if good machines are used, and samples containing much ergot should be rejected. See Rye, Parasitic Fungi. [W. G. S.]

Erica, a large genus of branching wiry shrubs with small leaves and flowers in axillary or terminal umbels, generally known as heaths. The species are most abundant in South Africa, where they often form large bushes with conspicuous brightly coloured flowers, which in many of the species are covered with a sticky substance. Half a century ago these South African or Cape heaths were among the most popular of greenhouse plants, but now only a few of them are cultivated for decorative purposes, the best known of these being *E. hyemalis.* In the neighbourhood of London alone, hundreds of thousands of this heath are grown

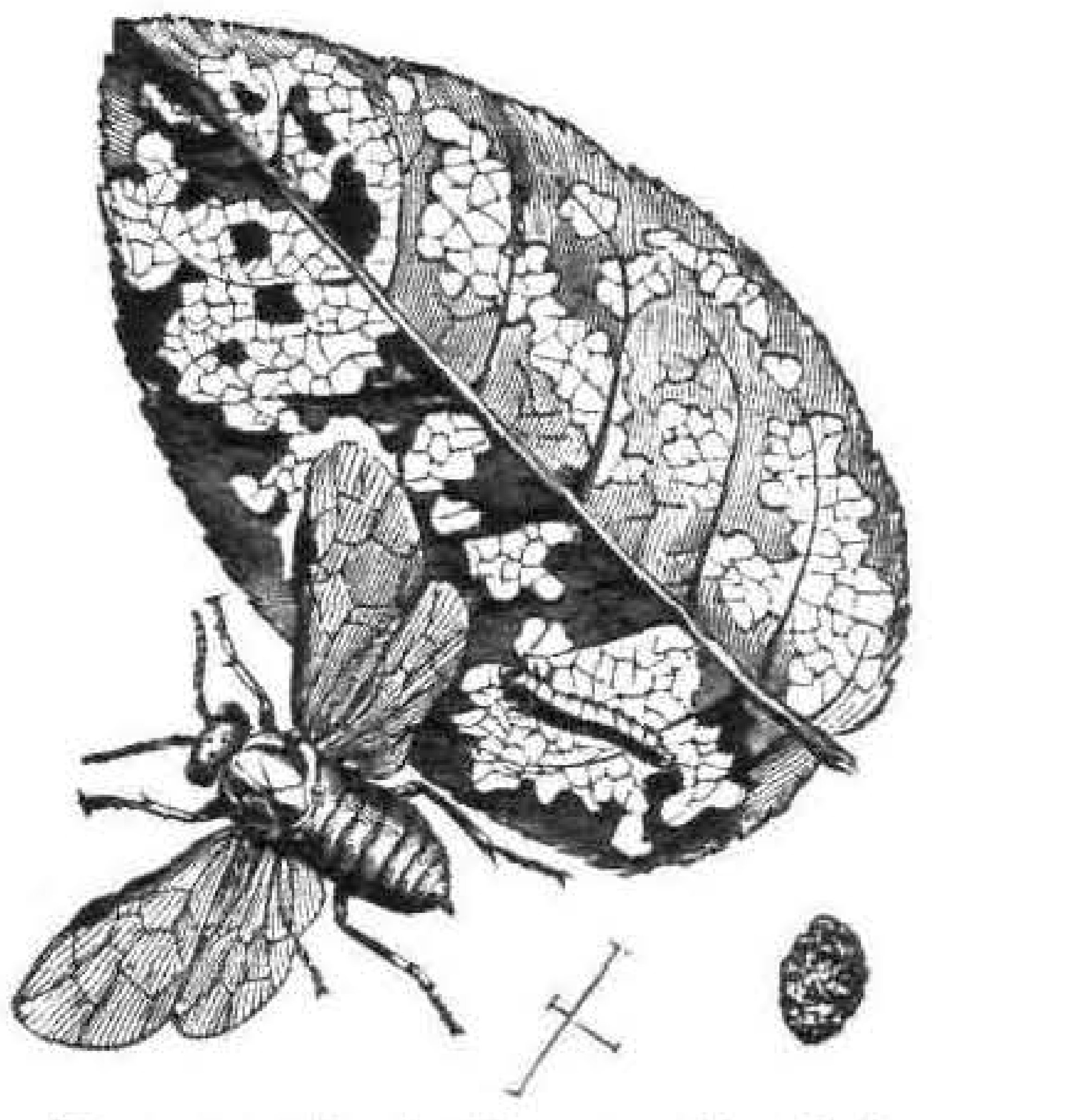


Erica hyemalis

annually and sold for the decoration of rooms, &c. The hardy species, that is exotic heaths which may be grown in the open air in the British Islands, include a number of really useful shrubs which thrive in any soil that does not contain lime or chalk. They flower freely and continuously, and as they are all evergreen they are useful for clothing large areas in parks, &c.; they are also good plants to grow where ground game is troublesome, as, like the rhododendrons, heaths are not interfered with by hares or rabbits. The two common British species, *E. Tetralix*, the cross-leaved heath, which has terminal clusters of bright-pink flowers produced in summer, and *E. cinerea*, Scotch heather, with red-purple flowers in long racemes, are both good enough to rank with the best garden shrubs. Then there are *E. carnea*, a dwarf species of spreading habit which flowers quite early in the year; *E. codonodes*, also known as *lusitanica*, the Spanish heath, which grows 10 ft. high in the south of England and has white fragrant flowers; *E. arborea* and *E. mediterranea*, from southern Europe; *E. australis*, from Portugal, the best of the red-flowered hardy heaths; and the hybrids *E. hybrida* and *E. Veitchii.* There are well-marked varieties of most of these hardy heaths, and they flower at different seasons, so that it is possible to make a selection of them which will one or the other be in flower from January to December.

[W. W.]

Eriocampa limacina (the Slugworm of the Pear and Cherry), a sawfly which, like many fruit pests, is widely distributed, occurring in Europe, America, and Australasia, the larva being known as the slugworm or sneg. It is a black sawfly, about ½ in. across the wings, and appears early in June. The female cuts irregular oval slits in the leaf with her sawlike ovipositor, and the eggs placed in these hatch in seven to twelve days, and the larvæ emerge on the upper side of the leaf. They are at first pale, but as they grow they become dark bottle-green and covered with slime, swollen in front and sluglike in appearance; they have six true legs



Slugworm or Sawfly (*Eriocampa limacina*)

and seven pairs of sucker feet; at the final stage they are yellowish and dry skinned. Having moulted their skin five times, they reach maturity, and are then ½ in. in length. They feed on the upper epidermis only, giving the leaves a blotched appearance at first; often later the whole surface is eaten away. When full grown they fall to the earth, burrow into it, form cocoons covered outside with earth, and change to pupæ, from which a second brood emerges in two weeks. The winter is passed in the larval stage in the cocoon in the soil, about 2½ in. below the surface; pupation takes place in the spring. Apparently three broods may occur, and the slugworms may then be found as late as October. They do considerable damage some years in cherry orchards, preventing the ripening of the wood by destroying so much leafage.

Treatment is best carried out by either dusting the trees by means of a sulphurator with helle-

bore and lime, or spraying with arsenate of lead. For a limited attack on cultivated land the surface soil may be removed in winter and either burnt or buried, and fresh soil replaced. [F. V. T.]

Eriocampoides æthiops (the Rose Sawfly), a sawfly about ⅙ in. long, with black, shiny body, the hind legs black and also the thighs of the front and mid pairs; the shins and feet in the latter white. Appears first in May. The eggs are laid in the midribs of the leaves in May and June.

The larvæ feed like the slugworm (see above art.), that is on the upper surface of the foliage, leaving the lower skin intact; they are pale-yellowish-green with orange heads, and reach about ⅜ in. in length. When mature they fall to the ground and pupate in oval earthen cocoons, from which another brood appears in about two weeks. There are several broods during the year (three at least). Winter is passed in the larval stage in cocoons in the soil under the rose bushes, and pupation takes place in the spring.

Treatment consists of spraying the foliage with arsenate of lead or hellebore wash. [F. V. T.]

Eriophorum. See COTTON GRASS.

Eriophyes avellanæ (the Nut-bud Mite).—This minute acarus has very similar habits to the Ribes species (*E. ribis*—see art. below), but it is quite distinct, and so far is only known to invade the buds of cob, filbert, and wild hazel nuts. It has recently increased in nut plantations, and is commencing to do some harm in parts of Kent and Sussex.

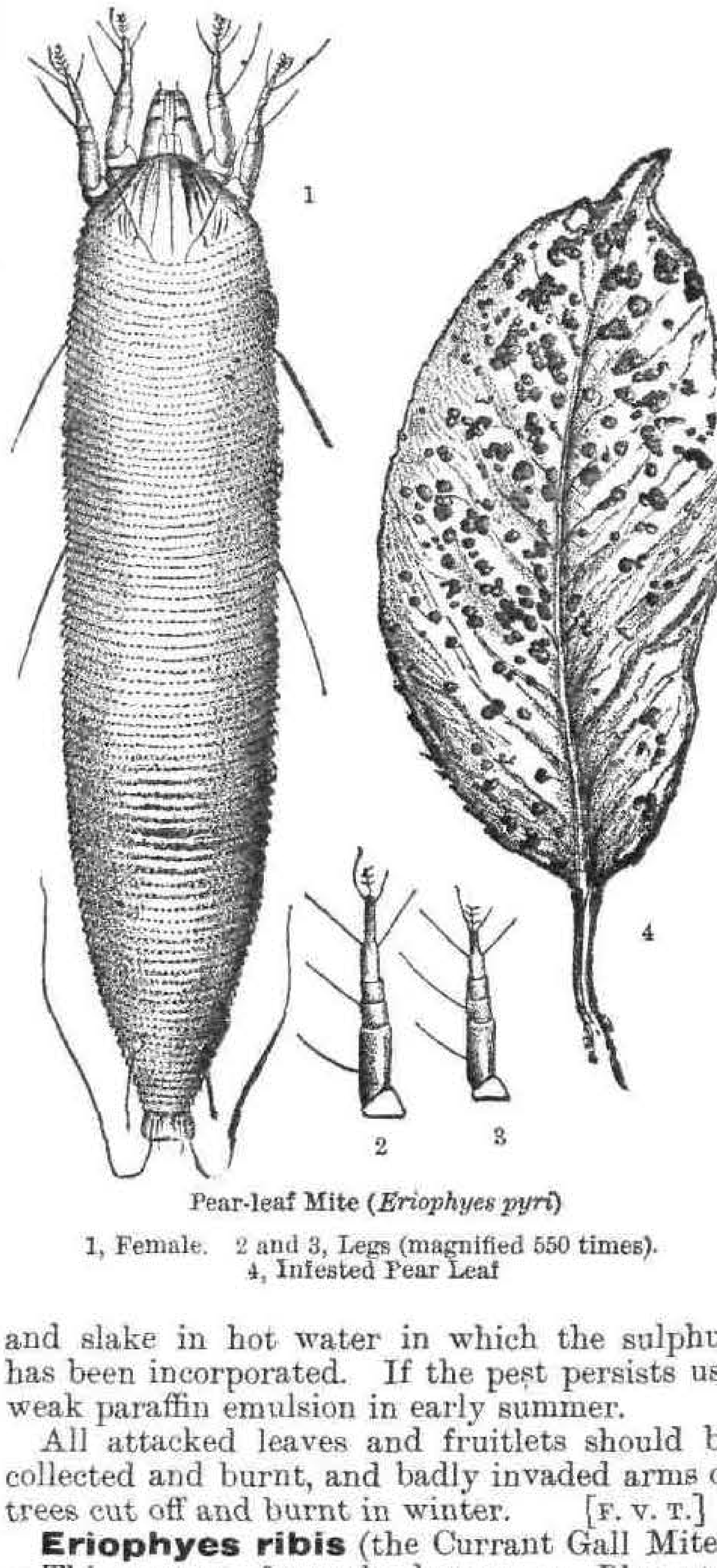
It may be kept in check by hand-picking, and it is advisable not to plant up nut orchards near hazel copses, and to clear out those in hedgerows near.

Eriophyes pyri (the Pear-leaf Blister Mite).—This mite is also very closely related to the mite producing 'Big Bud' in currants (see next art.), but its life-history is very diverse. Pear leaves are seen to be covered with small, pale, blister-like areas, which later turn black and the leaves die. If a section is cut of one of these leaves there will be found a few elongated, semi-transparent mites feeding and breeding in the soft mesophyll tissues. As the leaves die the minute acari migrate to other leaves and invade them, entering *via* the stomata on their under surface, and so on until the leaves ripen. During the last few years the young fruitlets have also been attacked and ruined; small rough red blotches appear on them, and then they turn black and fall. In 1907 this pest spread more rapidly than usual, and occasioned much damage. In the winter the mite is found sheltering in the bud scales, especially of the leaf-buds, but recently in the fruit spurs, and there it remains in a dormant condition, ready to invade the young opening leaves and blossom. It also occurs in Canada and the Cape. *Treatment* with lime salt and sulphur wash in early spring is said to be beneficial, if done just before the buds swell.

This wash is made as follows:—

Quicklime	6 lb.
Sulphur	3 ,,
Salt	3 ,,

Mix these together and enough water to slake the lime, whilst still hot add more water, and boil the mixture for forty-five minutes, after which make up to 10 gal. Equally good results are obtained with the more easily made Oregon wash. This is made by adding to the above 1 lb. of caustic soda, and then no artificial boiling is wanted. Mix the soda and lime together,



Pear-leaf Mite (*Eriophyes pyri*)

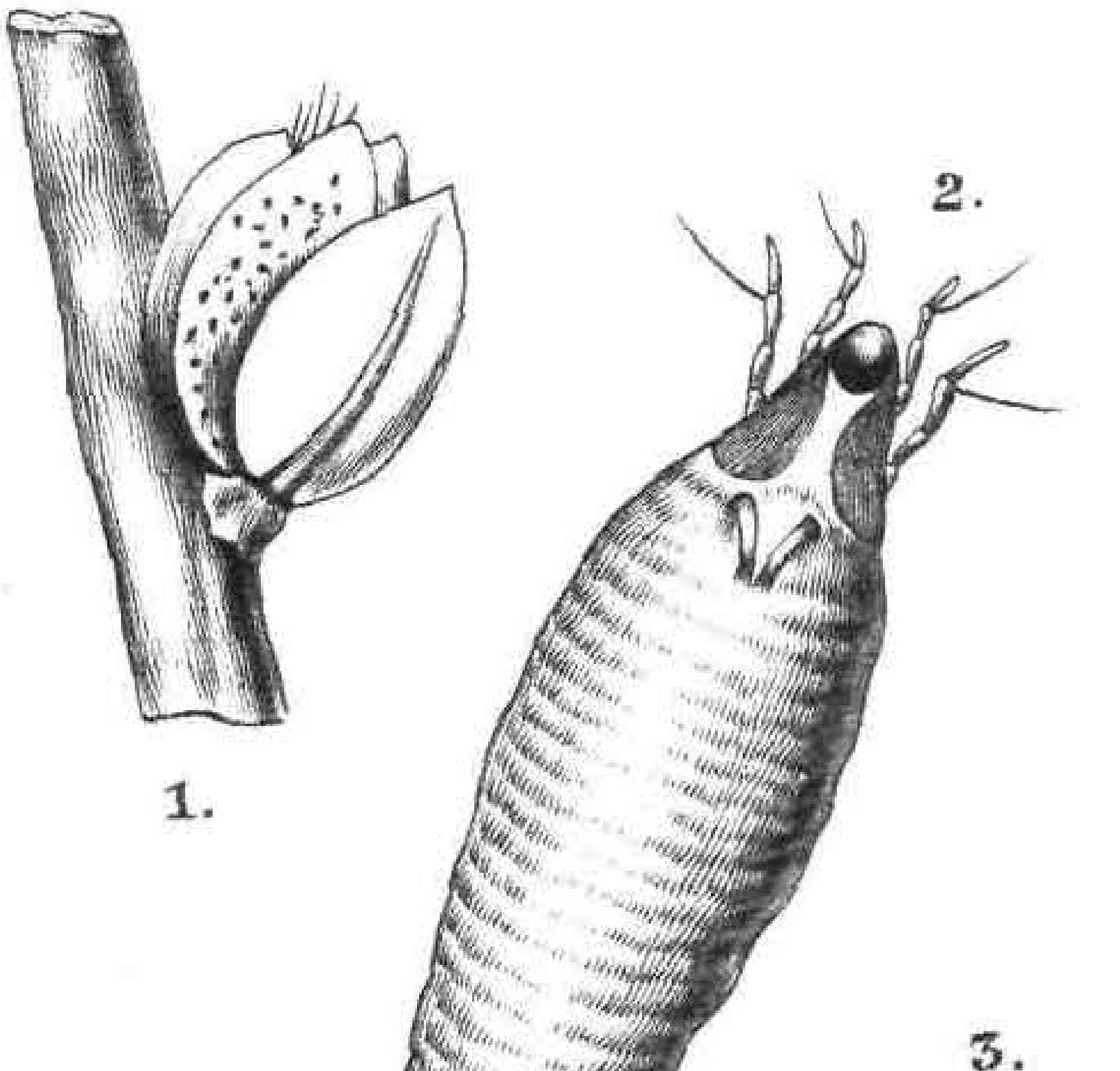
1, Female. 2 and 3, Legs (magnified 550 times). 4, Infested Pear Leaf

and slake in hot water in which the sulphur has been incorporated. If the pest persists use weak paraffin emulsion in early summer.

All attacked leaves and fruitlets should be collected and burnt, and badly invaded arms of trees cut off and burnt in winter. [F. V. T.]

Eriophyes ribis (the Currant Gall Mite).—This acarus, formerly known as *Phytoptus ribis*, is the cause of the well-known and serious disease in Black Currants—the 'Big Bud'. The presence of this pest has long been known in this country, but during the last fifteen years it has increased enormously, so much so that very few districts in Britain are now free from it. The rapidity with which it has spread is due not to natural but to artificial distribution. It also occurs on the Continent of Europe, but has not so far made its appearance in any other region. Owing to its prevalence and the frequently highly destructive nature of its work, thousands of acres of this paying crop have been grubbed up during the last ten years.

The disease manifests itself in the abnormal swelling of the buds, which frequently die, and which, if they survive, seldom produce any fruit spikes. The attacked buds become globular, and swell abnormally, sometimes to ½ in. across. On cutting open one of these abnormal buds, large numbers of minute semi-opaque elongated mites are found—these are the *Eriophyes ribis*. In size they reach $\frac{1}{100}$ in.; they have four short legs of nearly equal size, ending in a fine feathered bristle, a single claw, and a couple of simple spines. The cylindrical body is composed of about seventy rings; at the tail end are a pair of long bristles, and three large pairs on the



Currant Bud Disease

1, Infested bud. 2, Mite (*Eriophyes ribis*). 3, Same, younger. (All greatly magnified).

back, and also two small pairs. They deposit their eggs in the buds, colourless rounded bodies, in great abundance. The young are very similar to the adult. All stages may be found in a single bud. When a bud is killed they migrate to others. Some crawl from bud to bud, some appear to leap, others fall to the ground and re-ascend, and many are carried by bees, &c. When the old buds die off they migrate to new ones, and this migration is constant in spring and summer and even in winter. Mites may be found in the young buds in July, often in numbers, before they show any signs of swelling. They have also been found under the rough rind of the shoots in winter. Breeding may be said to occur all the year, but not in any degree in January and February. Migrations are constantly and irregularly taking place, and in the early summer, when new buds are forming, a long and constant movement takes place.

All varieties of Black Currants at present known are liable to the attack of this pest, but such as Black Naples and Baldwin are especially prone to attack; the only varieties which resist the Mite at all are the Boskoop Giant and the French. Recently Red and White Currants have been similarly invaded. There is no doubt the disease has been spread wholesale by infested bushes and cuttings. In fact, at one time the enlarged buds were considered to be particularly strong.

Treatment.—Satisfactory treatment is at present unknown. The nearest approach to anything like success is by fumigation with hydrocyanic acid gas, and this may be advised for young stock before being planted, but it must be done twice at about two weeks' interval, as the gas has no effect upon the eggs at the strengths so far employed.

Steeping cuttings and young stock in warm water at 118° F. for ten minutes will kill the mites.

Dusting with sulphur and lime has been advised, but it has little or no effect on the mites unless done every week during some six or eight months in the year.

At present all that growers can do is to hand-pick the swollen buds several times during the year, and cultivate from clean stock. Great care should be paid to the baskets in which the fruit is picked, as infection is liable to be carried from plantation to plantation by such means, as well as by the clothes and boots of the pickers.

There are several insects found feeding in the 'big buds', which, however, do no good in checking the pest, so no further reference need be made here. [F. V. T.]

Eriophyes rudis (the Birch Gall Mite).—This gall mite produces the so-called 'witches' broom' on birch trees. These dense, matted growths of twigs are often entirely formed by this mite; at the same time similar structures are formed by two fungi, *Exoascus turgidus* and *E. betulinus*. The mites live in the buds; they are $\frac{1}{200}$ in. in length; they resemble in shape that of the Currant Bud Mite. The formation of the 'witch-knots' begins with a diseased growth of the infested bud, which swells and becomes irregular; later the attached shoot becomes covered by buds, and by the successive forking of the twigs and growths of the same kind the knotted masses are produced. These masses may form pendent growths a yard long. The eggs are found in numbers in the buds in summer. The deformed masses should be cut off and burnt, as the disease gradually spreads. [F. V. T.]

Eriophyidæ (Gall Mites), a family of minute acari or mites, formerly known as Phytoptidæ. They are popularly called gall mites owing to the varied deformities or galls they give rise to on plants. These acari are white or semi-transparent, some almost glasslike; they are elongated in form, have four short legs projecting forwards, a thoracic shield and ringed body. The young are similar to the adults, and the eggs are comparatively large. The various stages occur together. Some kinds produce only

bud galls (see ERIOPHYES RIBIS), others galls on leaves (see ERIOPHYES PYRI). The latter pass the winter in buds. [F. V. T.]

Eristalis tenax (the Rat-tailed Fly).—The Rat-tailed Flies (Eristalis) take their name from the curious form of their larvæ, which occur in putrid water and even in liquid manure. The larvæ have a long tail-like appendage, which can be elongated at will and passed up to the surface film to obtain air. The commonest species, *E. tenax*, is often taken for a bee; its body is over ½ in. long, and the wing expanse about 1 in.; brown in colour, the abdomen with a more or less triangular tawny spot on each side near the base. They occur mostly in late summer and in the autumn. The presence of the larvæ shows signs of foul water. [F. V. T.]

Ermine. See STOAT.

Ernobius mollis.—This beetle lays her eggs in spring on the young shoots of newly felled pine and fir trees, especially those that have been attacked by *Hylesinus piniperda* and *Retinia buoliana*; the young larvæ bore into the pith and feed mainly on that substance; before they change to pupæ they bore a round hole to the extreme outer surface, so that the adult can easily escape. The beetles appear in spring; there is only one brood, the whole life-cycle taking just a year. The beetle varies from ⅙ to ⅕ in. in length, oblong, testaceous brown or ferruginous, clothed with rather thick pubescence; elytra rather long and parallel-sided, finely punctured; legs reddish-testaceous and slender. It is sometimes found in old houses, in old palings, and under bark. The genus Ernobius comes near Xestobium (Death-watch Beetles). Its importance in the forest is following on the damage done by Hylesinus. [F. V. T.]

Erodium, a genus of about fifty species of herbaceous perennials related to and resembling in habit the Geraniums. They are widely distributed, three species being natives of the British Islands. A few are cultivated as garden plants, being most suitable for rockeries, their elegant leaves as well as their purplish flowers entitling them to favour. They are popularly known as Heron's Bills. The best of them are *E. alpinum*, *E. macradenum*, and *E. romanum*. [W. W.]

Erratics, a term applied to the boulders of rock, not resting on their parent masses, which occur in regions where glaciers formerly prevailed. Sometimes, as in the mountain regions of North Wales or Donegal, they occur in such abundance as to cumber the ground and to need blasting for their removal. In Holland and the North German Plain, ice-borne blocks from Scandinavia furnish the farmers with their only stone for walls, road metal, and the basements of their houses. [G. A. J. C.]

Ervum, an annual pulse-bearing plant belonging to the nat. ord. Leguminosæ. See LENTIL.

Eryngium, a genus of herbaceous perennials belonging to Umbelliferæ. *E. maritimum*, the Sea Holly, a native of sandy seashores in Britain, is typical of the genus, the steel-blue of the prickly leaves and stems and the pale-blue thistle-like heads of flowers rendering it a very attractive garden plant. There are about one hundred species, which are widely distributed. Many of them are sufficiently hardy to be grown out-of-doors in this country. One of the most striking is *E. pandanifolium*, which has leaves 4 to 6 ft. long, and loose panicles of purplish flowers arranged in dense heads. Other good garden species are *E. alpinum*, *E. amethystinum*, and *E. Oliverianum*. They delight in light sandy

Eryngium Pandanifolium

soil and a sunny position. Increased by means of seeds or by division of the rootstock. [W. W.]

Erysimum, a genus of Cruciferæ, comprising about seventy species of annual or perennial herbs, and popularly known as Hedge Mustards. A few of them are grown in gardens along with such plants as wallflowers, the best being *E. Perofskianum*, a very showy hardy annual from the Caucasus, with stems about 1 ft. high, and bright orange-red flowers. *E. Marshallianum* is similar in habit, but has yellow flowers. *E. alpinum*, *E. pumilum*, and *E. pulchellum* are compact little perennials suitable for the rock garden. They are all easily raised from seeds. [W. W.]

Erysipelas.—This disease of the skin differs from others in being a diffusive inflammation involving the connective tissue beneath, and having serious constitutional effects similar to the shock which results from burns. It does not arise in animals, so far as is known, from causes other than injuries, whereby the bacillus is admitted. Burns and scalds specially invite its invasion, and gangrene of the parts often results. Swine erysipelas is also known as *swine fever* (see SWINE FEVER), and the true cutaneous erysipelas, which may affect other

animals, as when horses are burned with the singeing lamp, is prone to seize upon the ears of pigs when suffering from extremes of heat or cold (see EAR, DISEASES OF THE). The intensity, discoloration, and diffusion of the malady are diagnostic symptoms. *Treatment* consists in combating shock by quinine and other tonics, providing the most nutritious food, and placing the patient in a quiet apartment, and upon soft, dry bedding. Carron oil and lead solutions, dilute glycerine, and other remedies of the emollient class are the most suitable. A dusting of starch or wheat flour is often found to allay the acute irritability of the skin. [H. L.]

Erysipheæ, a family of fungi known as Powdery Mildews, and belonging to the Ascomycetes (see FUNGI). Typical examples are described amongst the parasitic fungi of GOOSEBERRY, ROSE, GRASSES, CLOVER, and GRAPE VINE. See also MILDEW. [W. G. S.]

Erythronium (Dog's-tooth Violet), a small genus of bulbs related to the tulips. They are quite hardy, *E. Dens canis*, the common European species, being an old and very pretty little border plant, the mottled leaves as well as the flowers being attractive. The plants grow naturally in moist woods, and under cultivation they are happy when planted in partial shade where the soil is fairly moist and light. They flower in spring. Other species are *E. grandiflorum*, which has large pale-yellow or white flowers; *E. Hendersoni*, lilac; and *E. Howelli*, pale-purple. *E. americanum* is known as the Yellow Adder's-tongue. [W. W.]

Escallonia, a genus of evergreen shrubs, natives of the temperate regions of South America. They are too tender to thrive out-of-doors in the British Islands, except in the warmer parts or against a wall. Some of them are admirably adapted to form fences, particularly in gardens near the sea, *E. macrantha*, a dense grower with ovate shining leaves and racemes of bright-red flowers, being largely used for this purpose. *E. Phillipiana* is hardy in the neighbourhood of London, where it forms a compact small-leaved shrub 5 ft. high, and in July is thickly clothed with white flowers. There are several hybrids in cultivation, the best being *E. langleyensis*, raised from the two species above named, and *E. exoniensis*, supposed to be from *E. Phillipiana* and *E. rubra*, the latter a small edition of *E. macrantha*. All these plants grow well in ordinary soil, and they may be trimmed or cut as freely as privet or hawthorn. [W. W.]

Eschallot, or **Shallot** (*Allium ascalonicum*), a small bulbed onion, native of Palestine, and largely grown in some countries in the same way as the common onion. It has a less offensive odour than garlic, and is therefore sometimes used in preference to it in a raw state for flavouring. It has a well-marked habit in the copious production of offset bulbs, or rather the mature bulbs divide into what are called 'cloves', which speedily grow to full size. The Eschallot requires a light, moderately manured soil. As it does not produce seeds, it is multiplied by planting the small bulbs about 4 in. apart in rows. This is done in February or March, when the soil is in a suitable condition for the bulbs to be only just buried. After they have begun to grow, it is a good practice to expose the bulbs by removing the soil from about them. The bulbs may be pulled up and dried in autumn, after which they will keep about a year. [W. W.]

Eschscholtzia, a genus of showy, hardy perennial and annual herbs related to the poppies. They are distinguished by the upper part of the calyx forming a sort of cap, which encloses the petals and is pushed off when they expand. Several species are grown in gardens, the best known, *E. californica*, being one of the showiest of summer-flowering annuals. The leaves are finely divided, and the poppy-like flowers are bright-yellow, orange, pink, or white. The seeds are sown in the open border in April, and the plants, which soon come up, may be left to look after themselves. They are excellent for covering borders and beds in which bulbous plants such as daffodils, tulips, &c., are grown. With regard to soil, position, and moisture, what suits poppies also suits Eschscholtzias. [W. W.]

Escutcheon.—The hair on the udder and thighs of cows grows in two different directions, one part pointing upward and the other part pointing downward, thus forming a fringe at their line of junction. The area of upward- and outward-pointing hair enclosed by this fringe is termed the 'escutcheon' or 'milk mirror'. A theory has been formulated in France by M. Guenon which connects the form of the escutcheon with the milking capacity of the cow. See GUENON'S SYSTEM.

Esker, an Irish term meaning a ridge, now restricted to the ridges of gravel common in countries where ice sheets have prevailed. In Scotland these are called *kames*. Eskers rise with steep flanks from the surrounding land, and often run across country independently of the present drainage. Viewed from a height, they resemble great serpents on the surface of the lowland. In their loops and hollows they may include lakelets; but their own surface is usually well drained. Grass grows well upon them, whence the name 'green hills' often associated with them in Ireland. In boggy regions, roads are often carried along their crests.

When quarried into, they are seen to consist of water-worn gravel; many of the stones, however, may retain traces of glacial striæ. Fresh sharp sand and coarse gravel may be found interbedded in the same esker, and the stratification is roughly parallel to the slopes of the ridge. Though formerly ascribed to marine currents, there is no doubt that the explanations of Winchell, Holst, Hummel, and Goodchild, between 1872 and 1878, are far more in agreement with the facts. The two former observers argued that streams on the surface of an ice sheet, washing along stones from the moraines, work their way downwards; the two latter authors show how streams beneath the ice tend to work their way upwards on a pile of water-worn boulders and sand. In either case, on the melting of the ice, a ridge of detritus, formerly confined by ice on either side, remains

to mark the course of the old waterway. Kames or eskers are common in southern Scotland, as in Ireland, and adjacent ones have a similar trend, as if belonging to a system of approximately parallel streams. Their surface, though dry and stony, may furnish pasture, or may even be ploughed over. In Tyrone, Roscommon, and elsewhere, the eskers yield an easily obtained gravel for the roads. [G. A. J. C.]

Espalier, a term used to describe a particular method of training for fruit trees, literally trees trained to a lattice work. The side branches are made to grow horizontally, usually by fastening them to upright stakes temporarily, or by means of strained wire strands fixed to uprights. The nurserymen grow large numbers of pears and apples by the former method, to be planted either against fences or walls. Trees thus trained produce first-class fruits, but they require a good deal of attention from the pruner. In addition to the horizontal espalier there is the gridiron espalier, in which two main branches are trained horizontally, and from these upright branches are trained at equal distances apart. These branches must all be in the same plane. Espaliers are often made to serve the purpose of a garden fence. [W. W.]

Esparto Grass. See STIPA TENACISSIMA.

Essential Oils. See OILS.

Essex Pigs. — These have altered very much in form and character during the last half-century; the pretty and for a time fashionable small black pig, which owed much of its rotundity and ability to convert meal into lard to the Neapolitan blood in its veins, has ceased to exist in the British Isles, although some few herds of the breed, designated Essex, are still to be found in Canada and U. States. The particoloured or sheeted pig, which was very general on the Cambridgeshire side of the county, was crossed by the Berkshire, and later by the Large White; but the peculiar and distinctive colour still persists in showing itself, especially on those farms where the owner makes it a rule to reserve the peculiarly marked pigs for breeding sows, to be crossed with the Yorkshire boar. These sows are prolific and good sucklers; the youngsters grow quickly when on the sow, and if sired by a thick-fleshed, nice-quality boar, fatten readily into pork pigs of about 100 lb. and into bacon pigs of some 160 lb., both dead weights. A considerable number of white sows of no particular type and somewhat deficient in quality are kept in some parts of the county. These are mated with Large White or Large Black boars, and produce hardy pigs of quick growth, and very suitable for selling as sucklers to those dealers who send them into the counties where dairying and cheesemaking are general. Some years since, a large proportion of the sows kept in Essex were black in colour, rather high on leg, and flat-sided, but they were long in body, especially good mothers, whilst their produce would grow fast and fatten readily when some months old, and furnish a very good carcass of pork for either the fresh-meat trade or for conversion into that old-fashioned bacon which was salted so heavily in order that it could be kept for the summer's consumption, a very important item in the farmhouses of that period. When the breeders of black pigs became infected with the herd-book fever, an attempt was successfully made to unite the breeders of the largest type of black pigs in the eastern counties, and those who had been breeding a thicker and coarser kind of large black pig in the west of England. Fears were expressed that a difficulty might arise as to the determination of the official type of the Large Black pig. The initial difficulty of drawing up a scale of points was overcome partially by not adopting too critical a definition and value of the various points. However, the expected is said to have happened, and there still exists some considerable difference in the style, substance, and quality of bone and flesh in the pigs bred in the west and the east of England. This is brought prominently forward at the Royal and other shows, when pigs from the two divisions of the country come into competition, as the class of pig which secures the major portion of the awards will vary according to the district from which the judge for the particular show is selected. Although this uncertainty of type may be unavoidable to a limited extent, yet it is none the less unfortunate, as the Large Black pig has many good qualities, such as hardihood, prolificacy, and quick growth; whilst a cross with a Large White boar results in an ideal fat pig for conversion into mild-cured bacon with the desired light-coloured skin. Large numbers of fat pigs bred in this way are weekly sent from Essex, Suffolk, and Cambridgeshire to Calne and other bacon-curing centres, to the profit of both pig breeder and feeder and bacon curer. Essex has for many years been noted as a pig-breeding county, and although large areas of cultivated land have been laid down to grass, and milk production for the London market has largely taken the place of cheese and butter making, the pig population in the county shows little signs of decrease. [S. S.]

Estate Agent. See AGENT, LAND.

Estate Management. — Granted that in accordance with British custom the landlord equips the farm for cultivation, while the tenant pays him for the privilege of developing the fertility of the land, the ideal system of estate management is where we find the two being carried on simultaneously in a thoroughly up-to-date manner. This implies enlightened tenants possessed of sufficient means to farm in accordance with the latest teachings of science, and a manager both able and willing on his side to keep in the front rank of advancement. But it is rare to see the latter so well posted up in the affairs of his department as a leading farmer is in his. This is far from what ought to be. The equipment of the estate embraces buildings, fences, roads, and drains. Each of these items is suggestive of considerable initial outlay, and a continuous drain thereafter to maintain them in proper order; and where the manager comes short of what ought reasonably to be expected of him, there is inefficiency bound to be present in large degree. Only by the exercise of close attention to detail can unnecessary

expense be avoided. Buildings that happen to be more or less unsuitable for the purpose for which they were intended mean waste of money to some extent to the landlord, and both waste of time and loss of profit to the occupier.

The well-trained manager is alive to the advantages of adapting buildings as far as possible to the needs of the farmer, in order to save the latter labour in dealing with his stock whether alive or dead. The man thus far advanced is capable of seeing that the houses are properly erected and are worth the money they cost. It is well both for landlord and tenant when affairs in this department are on a footing of this favourable nature. It is well for the labourer too, because he will be likelier to have chance of a place that he can make into a home. The manager who knows the advisability of seeking to adapt the homestead to the requirements of the farm, and tries to do so, will be equally ready to identify himself with the home life of the labourer and make matters easier for him in his toilsome yearly round.

Estate managers as a body seem to be further back in the matter of fences than in buildings. Crooked or tortuous fences are a hindrance to profitable tillage of the soil. Straight lines suit farming operations. Fields with parallel sides admit of the minimum waste of time in the work of cultivation. But enclosures of this form are not always practicable. Neither are they picturesque, some may say. They are not altogether practicable where the surface of the ground is much broken up or otherwise diversified in character or outline. Where they happen to be practicable, however, they should be introduced in order to be in keeping with the higher class of machines that are now available to farmers. We do not suggest any radical attack on the existing state of matters as regards fences; rather, a gradual improvement of their arrangement as opportunity arises. This will not interfere very much with appearance. There will be plenty rugged places left for effect even should all good land come to be fenced as we describe. It seems reasonable to anticipate the introduction ere long of a motor that will largely take the place of the horse in tillage work. When this comes to be established, more room on the cultivated land will be a necessity, and small fields with twisted boundaries will have to give place to large enclosures, as far as possible of a rectangular shape. Meantime there is no excuse for the manager neglecting to make matters easier in this connection for the farmer. Too often, however, do we see him allowing favourable opportunities of reforming affairs of this sort to slip past, generally no doubt because he fails to grasp the situation.

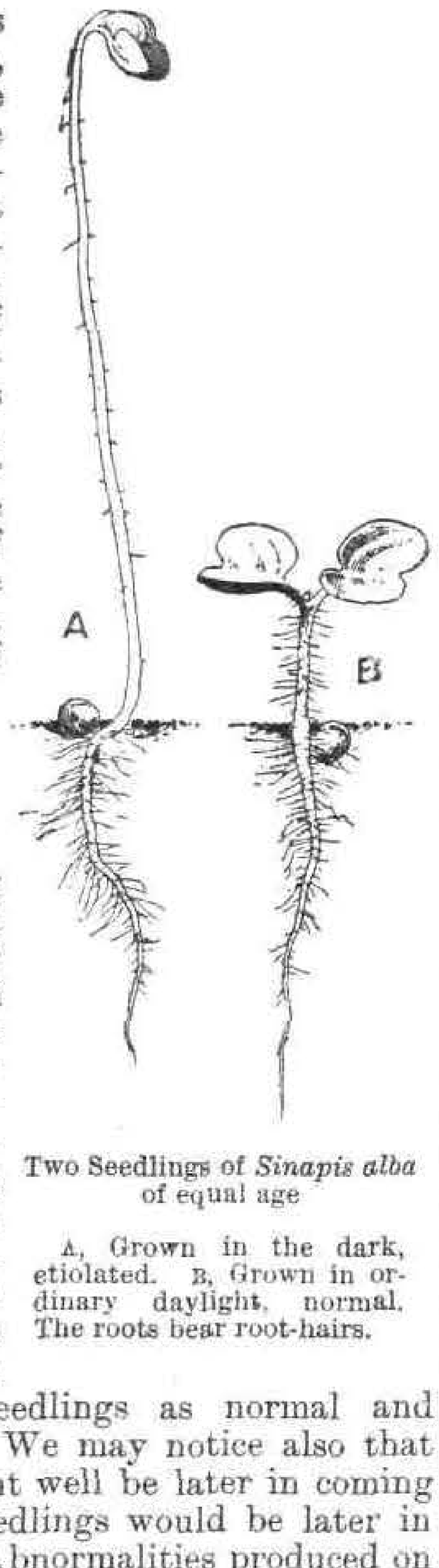
If the manager is fairly well up in the two departments—buildings and fences, he will not be lacking in acquaintance with the principles and practices connected with roads and drains. If behind, however, with the former two, he is almost sure to come short in the case of the latter as well. His efficiency as a manager of the outside affairs of the estate depends entirely upon his skill in applying the fundamental principles of these four branches to practice at both steading and cottage and in the fields.

There remains another important branch of estate management to be considered—that of covenant making with tenants. On success in this depends the nature of the relationship that is to hold good between owner and occupiers of the estate. It takes two to make a bargain, so that the estate manager is not alone concerned in this; but the advantages are nearly always on his side, in so far that he is in the position to state terms and has a pick of offerers. It is the last condition that is apt to lead the landlord's agent astray. Undue competition cannot act otherwise than to inflate prices; and when a farm is taken too dear the tenant is never satisfied so long as the bargain endures. It follows that there can be no pleasant relationship between one so placed and the owner of the land. All the same, no rule can be laid down the observance of which would solve the difficulties surrounding the question. It may be taken for granted, however, that no landed proprietor is so shortsighted as to wish for rents that are higher than the nature of the land and local circumstances authorize. How to arrive at the fair rent is the crux. The efficient manager we assume under our ideal system of estate management should be in a position to do so. It ought not, of course, to be the rent that a man head and shoulders above his fellow farmers can pay on account of his strength in some special line, but one based on what the average farmer of the district can meet without strain. Land courts are being urged as a way out of the difficulty, but outside interference of this sort, if pushed too far, instead of leading estate management towards more ideal lines will go far to break up the relationship between landlord and tenant that has helped so much to bring British agriculture to the high state it occupies. [R. H.]

Etiolation is the collective name for certain peculiarities which green plants display when they are grown continuously in darkness, when they exhibit what is commonly known as a 'blanched' or pallid condition. One striking symptom is paleness of colour. When plants are forced to grow without light, parts normally green cease to develop the green colouring matter (*chlorophyll*) and become white or yellowish-white, as is easily seen when we turn over a stone under which grass has been growing —the grass there is quite blanched, not at all green. This means that presence of light is one condition necessary for the development of the green colouring matter. In the practice of agriculture this very important fact that without light there is no chlorophyll must be reckoned with, for it limits the thickness at which plants can be grown for profit. If too thickly grown, the plants are more or less in continuous darkness and can develop chlorophyll only to such a low extent that the wants of the plant are not satisfied, and the result is loss rather than gain on the resultant crop.

Another well-marked symptom of etiolation is abnormal lengthening of the stem. If, for example, we germinate two mustard seeds side

by side on damp earth and keep one of the seeds in darkness, it will be found that the normal seedling produced in light has the stem below the cotyledons only ¼ in. long, whereas the other seedling grown in the dark has its corresponding stem twelve times as long, that is, 3 in. This fact, again, has important bearings on practical agriculture, for it shows us that plants with very different properties may be produced from seeds exactly the same. Nature uses the normal seedling, for unless in special cases it sows on the surface and keeps its seedlings exposed to the light, whereas the farmer buries his seeds, and rightly so, in order to secure the warmth and moisture necessary for successful germination. But by so doing he produces abnormal seedlings, the amount of abnormality depending on the shallowness or deepness of sowing. A mustard seed, for example, might be buried to a depth of 3 in. and yet be able to produce a seedling, for there is enough of nourishment stored away in the mustard seed to make an etiolated stem of a 3-inch length. If buried deeper the seedling would be so abnormal that it could never reach the light, and so must perish. In proportion as we sow more and more shallow, in the same proportion our seedlings become more and more normal or natural, and the politic plan is to sow as shallow as possible in order to produce seedlings as normal and natural as possible. We may notice also that deep-sown seeds might well be later in coming forward, since the seedlings would be later in reaching the light. Abnormalities produced on this principle are well under the control of the practical man, for he can sow thick to produce abnormal lengthening or 'drawing up', as in the case of a young forest when long clean boles are the object, and as in the case of oats when long fine straws are wanted, or he can box his potato tubers when normal plants of the highest possible tuber-bearing capacity is the object in view.



Two Seedlings of *Sinapis alba* of equal age

A, Grown in the dark, etiolated. B, Grown in ordinary daylight, normal. The roots bear root-hairs.

A third symptom of etiolation, and one intimately connected with the second, is the excessive tenderness displayed by parts abnormally lengthened. This must be so, since the lengthening is accompanied by increase of bulk without corresponding increase of food supply. In fact, tenderness means less solid substance and more water, greater sensitiveness to cold, and special susceptibility to disease. We see, therefore, and in connection with seedlings more particularly, how dangerous it must be to expose an etiolated young plant to a trying season, or to produce etiolated clovers on land where there is liability to clover sickness, or etiolated turnips where there is liability to finger-and-toe, and so forth.

A fourth symptom of etiolation is connected with the leaf. A plant grown in darkness has the leaf-stalks specially long, with the leaf-blades specially small and folded up as if in bud. This is the case, for example, when rhubarb is grown under a barrel or in a darkened house, and so is it also in the case of celery when earthed up and blanched.

The processes in plant growing called blanching, drawing up, and forcing are thus seen to be intimately connected with the phenomena of etiolation. [A. N. M'A.]

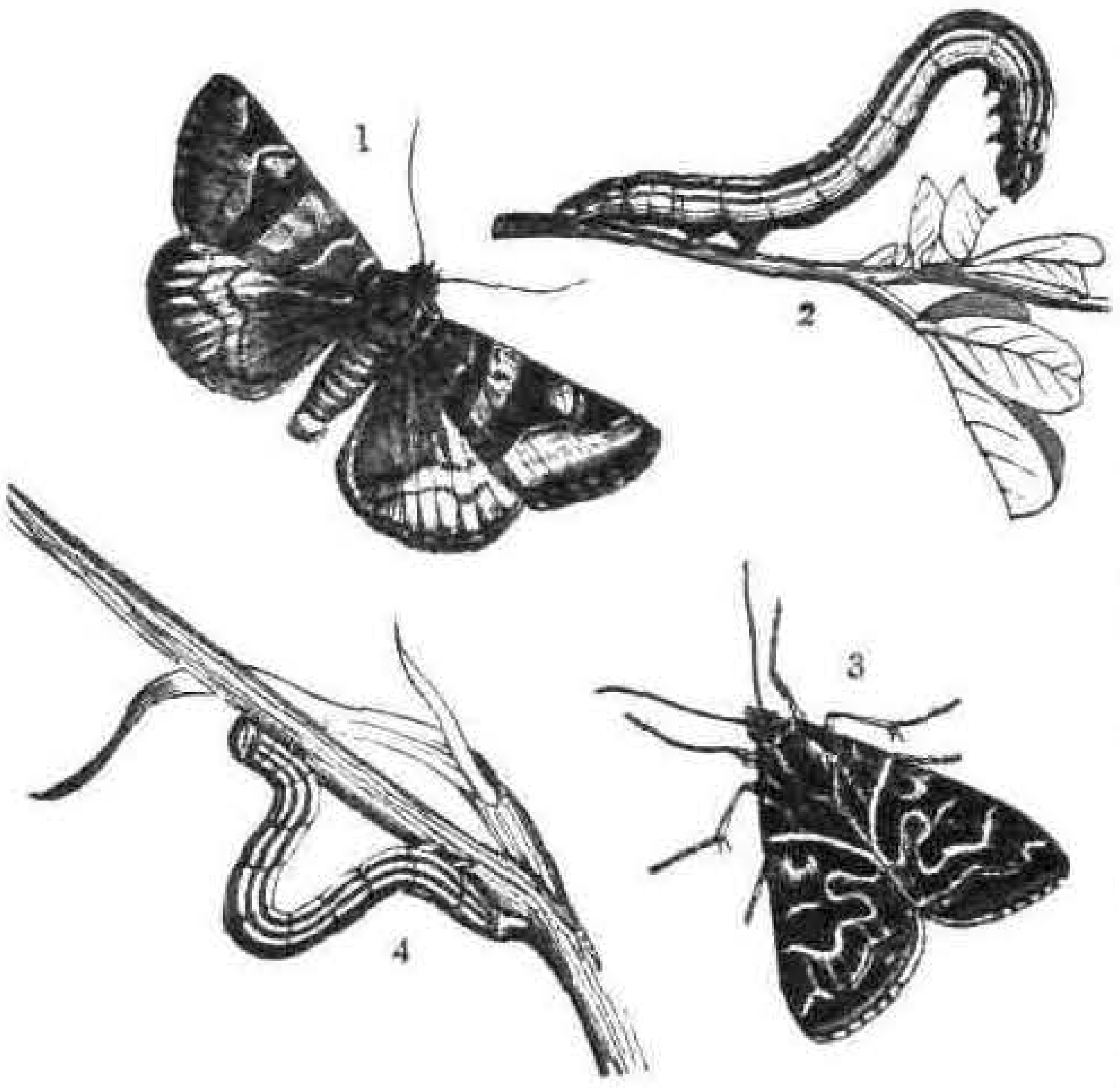
Euacanthus interruptus (Hop Frog-fly) is sometimes very abundant in hop grounds, and from its living upon the sap by means of its beak, it exhausts the plants considerably. It frequents hedges and grassy places, where it seems to breed as early as May. In July and August it resorts to the hops, and has been collected in vast quantities, principally in the weak plantations. Four, five, and even a dozen have been taken from one leaf. It is at least ¼ in. long, of a deep-yellow colour, variegated with black, forming spots on the head, which is crescent-shaped, two patches on the oval thorax, and two oblique stripes on the front wings; the antennæ are very thin; the eyes are black; the face oval and terminating in a short stout beak; the hind legs are long, the tibiæ spiny. The insects are subject to variation, some having red markings on the front wings. The eggs are white, long, narrow and cylindrical, rounded at the ends. The 'jumper' occurs on the young hops early in the summer. All stages occur up to July, when maturity is reached. They feed by sucking out sap on the under sides of the leaves, and their cast skins are frequently to be found attached there. This insect is common on other plants than the hop. Nothing can be done to check them but jarring the attacked bines over tarred boards. [J. C.] [F. V. T.]

Eucalyptus, a large genus of evergreen trees almost entirely confined to Australia, where they often form large forests. Some of the species grow to an enormous size, *E. amygdalina* being the loftiest tree in British territory, attaining not rarely a height of 400 ft.; *E. globulus*, the Blue Gum; *E. marginata*, the Jarrah; *E. rostrata*, the Red Gum, and *E. diversicolor*, the Karri, are other gigantic trees, the timber of which is of considerable commercial value. A few of the species may be grown out-of-doors in the warmer parts of the British Islands, but none can be said to be really happy with us. The hardiest are *E. coccifera*, *E. Gunnii*, and *E. urnigera*, which are natives of Tasmania; but the Blue Gum is the most generally grown, as it is easily raised from seeds, grows quickly, and its

large blue-green foliage is attractive. There is a great difference between the leaves of the young plants and those of mature trees; for instance, in *E. globulus* they are broad and stem-clasping on young plants, but long, falcate, and petiolate on mature trees. [W. W.]

Euchelia jacobeæ (the Cinnabar Moth).—This moth measures $1\frac{1}{2}$ to $1\frac{3}{4}$ in. across the expanded wings; the fore pair are dull-black, with a narrow red stripe near the upper margin, and two spots on the outer margin of the same colour; the hind wings are scarlet, with a narrow dull-black margin. The moth appears in May and June, and flies at daytime. It lays its eggs normally on ragwort, but now and then on potatoes and groundsel. The larvæ live gregariously; they are ringed with orange and black, and reach 1 in. in length. Being ravenous feeders, they strip the potatoes very rapidly. Recently tomatoes have been attacked in the Channel Islands. All ragwort and groundsel should be excluded from potato beds. [F. V. T.]

Euclidia glyphica (Burnet Moth).—Fig. 1 is of a plum colour, with slender antennæ; the



Euclidia glyphica—Burnet Moth (figs. 1 and 2). *Euclidia mi*—Shipton Moth (figs. 3 and 4)

upper wings are barred with chocolate; the under wings are orange, black at the base, with two black, wavy, transverse lines. The caterpillar (fig. 2) has only twelve feet, and forms a loop in walking. It is of a buff colour, and striped, with the head and belly brown. It feeds upon the purple clover (*Trifolium pratense*).

E. mi (Shipton Moth) is greyish; the wings are variegated with black patches, edged with ochre, forming in the centre of the upper ones two laughable profiles, likened to the once-famous witch Shipton, from whence the English name (fig. 3, resting with the wings closed); the under wings are black, with bright ochreous spots, forming two wavy bars. The caterpillar (fig. 4) is similar to the foregoing one, but it is of a whitish lilac, sometimes inclining to ochre, and striped. It also feeds upon clover, lucerne, yellow medick (*Medicago falcata*), and grasses. Both the above moths fly about clover fields in summer, in the daytime, especially when the sun shines. [J. C.] [F. V. T.]

Eumenidæ (Solitary Wasps), a family of Hymenoptera called Sand or Solitary Wasps, which form their nests of a few cells composed of mud or clay, either in the ground or in wood, and the hollow stems of brambles, &c. The best known are the Sand Wasps (Odynerus), black and yellow species resembling small wasps. They are all of great benefit, as they provision their nest cells with caterpillars, weevils, flies, &c., for the larvæ when they hatch to feed upon. [F. V. T.]

Eumerus strigatus (the Small Narcissus Fly).—Frequently found feeding in Narcissi with the grubs of the large Narcissus Fly (*Merodon equestris*) are smaller larvæ, which prove to be those of *Eumerus strigatus*. All the members of this genus feed in the bulbs of plants. This fly appears in April and May; it is $\frac{1}{3}$ in. long, with wing expanse of rather over $\frac{1}{2}$ in., shiny black in colour; the thorax brass-coloured, with two hoary stripes; abdomen with three oblique curved hoary bands on each side. The hind femora of the legs armed beneath with twelve teeth; halteres yellow. The adult Eumerus seem to mimic in habits small acuminate Hymenoptera, and the larval habits are the same as those of Merodon. This species is also recorded on the Continent by Bouché as destroying onions. The larvæ occur in July, and pupate in a puparium case in the bulbs. All bulbs should be fumigated before being planted in districts where this pest and the Merodon occur. [F. V. T.]

Euonymus, a large genus of trees and shrubs with opposite, persistent, or deciduous leaves; order Celastrineæ. Some of them are popular garden plants, but only the deciduous species are perfectly hardy, the evergreen species being liable to injury from frost, except in the warmer parts of the British Islands. *E. europæus*, the Spindle Tree, is a native shrub or small tree up to 12 ft. in height, and in autumn when its scarlet fruits are ripe it is very ornamental. *E. americanus* and *E. atropurpureus*, both natives of North America, form large bushes, and have brightly coloured fruits. The most useful species, however, is *E. japonicus*, an erect shrub, 10 ft. high in favourable situations. The type has glossy evergreen leaves, and there are varieties with silver and gold variegation. They are used as border shrubs in the warmest districts, but their greatest value is for window gardens. *E. radicans*, a dwarf trailing species with green or white and green leaves, is an excellent border plant, and it also serves well in some districts for furnishing walls, to which it clings like ivy. The leaves are small and evergreen, and the plant thrives in the poorest and driest of soils; it even grows well under trees. In the neighbourhood of London this plant is used in a variety of ways with excellent effect. The species are easily propagated by means of cuttings; they are also very good natured when severely pruned, standing the knife as well as Box or Aucuba. [W. W.]

Euphorbia, the type genus of a very large order including small herbs, shrubs, and large trees. There are about 600 species of Euphorbia alone. They all have milklike sap, which is more or less acrid and poisonous. Some of the species are natives of these islands, the Caper Spurge, *E. Lathyris*, the Cypress Spurge, *E. Cyparissias*, and *E. amygdaloides* being abundant in some parts. A few are grown in gardens as decorative plants, the bright-yellow colour of the leafy bracts surrounding the flower-heads being their chief attraction. A considerable number of tropical and subtropical species of Euphorbia are grown in greenhouses, the best being *E. fulgens* and *E. pulcherrima*, the latter being what is generally known as Poinsettia. See also SPURGE. [W. W.]

Euphrasia. See EYEBRIGHT.

Eupithecia assimilaria (the Hop and Currant Pug Moth).—This species is a little over ¾ in. in wing expanse; fore wings light blackish-brown with a whitish line across. It occurs in May and June. The caterpillar is yellowish-green, thickly covered with small yellowish-green raised spots, division of segments yellow, a dark-green line along the back and one below it on each side; very variable. The larva occurs in September and October on hops and black and red currants. It pupates in an earthen cocoon in the soil, the pupæ being yellowish-green. The larvæ do little damage to hops, but are now and then harmful to currants, and may be killed as the following species is. [F. V. T.]

Eupithecia rectangulata (the Green Pug Moth).—The caterpillars of this moth feed on the buds and blossoms of the apple and pear. The moth measures about ¾ in. in wing expanse; the fore wings deep-green, the first line dark-grey and curved, second line dark-grey and bent near upper margin, space between the two dull-grey-green, third line pale-green, outer margin clouded with grey; central spot blackish. The moth appears in May, June, and July. The caterpillar is pale-yellowish-green, with a central line of rusty-red or dark-green or this may be absent, divisions between the segments reddish, side line yellowish-green. It does great damage to the opening buds and blossom trusses, being found in April and May and even into June. When mature it pupates in the ground in an earthen cocoon, the pupa being deep-red at and towards the end; thorax and wing cases yellow tinged with olive-brown. *Treatment* consists of early spraying with arsenate of lead wash. [F. V. T.]

Eupteryx auratus (the Spotted Potato Frog-fly). — The spotted potato 'frog-fly' was referred to by Curtis as *Eupteryx picta*. It is a very common insect, which often occurs in numbers not only upon potatoes but also upon nettles and various low plants. The wings are yellowish or greenish-yellow with a wide irregular fuscous stripe down the middle, so that there are two large and two smaller yellow basal ones on the outer edge of the wings, and three smaller ones on the inner edge, the apex white, and a pale spot near it; head and thorax spotted with dark-brown; legs all yellow. Abdomen black with yellow markings. They feed on the potatoes in a similar way to *Chlorita solani*, and may be caught by jarring them on to tarred boards. [F. V. T.]

European Agriculture. — AUSTRIA-HUNGARY.—Agriculture in Austria and Hungary is under the charge of two separate Departments, and statistics are returned separately for these two main divisions of the empire.

In Austria the area under corn crops is a little under or over 17,200,000 ac., an increase having been shown in recent years. The cereal most extensively grown is rye, which usually covers from 4,800,000 to nearly 5,000,000 ac. Oats are grown on about 4,500,000 ac., and wheat and barley each on 2,800,000 to 2,900,000 ac. The average yields in five recent years were 19·07 bus. per acre for rye, 23·07 for oats, 21·83 for barley, and 17·49 for wheat. Other cereals are grown to a much smaller extent, no separate crop among them besides maize covering over 500,000 ac. They include buckwheat, pulse, rice, and mixed corn. Rice is an insignificant crop, grown on only about 740 ac. Potatoes occupy 3,100,000 to 3,250,000 ac., yielding only a little over 3½ tons per ac.; while mangolds and turnips are grown to a surprisingly small extent. Sugar beet in recent years has varied in area from about 538,000 to 642,000 ac. Hops have increased in area, the latest available area being 57,949 ac. for 1907. Vineyards occupy about 615,000 ac., and tobacco is grown on 12,500 to 13,000, flax on about 179,000, and hemp on about 70,000. Other crops grown to a small extent are rapeseed, olives, mulberries, and chestnuts. Clover ranges round an average of 2,500,000 ac., and rotation grasses cover a little over or under 314,000 ac., while permanent grass, including Alpine meadows, is credited with about 14,000,000 ac. The total area under crops and grass in 1907 was 45,433,602 ac., of which 26,314,646 were arable. Woods and forests are returned at 24,174,443 ac.

The latest available returns of live stock in Austria are 9,511,170 cattle, 3,621,026 sheep, 1,019,664 goats, 4,682,654 pigs, 1,716,488 horses, and 66,647 mules and asses.

The predominating proportion of the land of Austria is in great estates, while small ownership ranks next in importance, properties of medium size being much fewer than in most other countries.

With respect to agricultural education, information as to this and other countries, collected from official sources in 1907–8 by the present writer for the Journal of the Highland and Agricultural Society of Scotland, is available for reference, and is acknowledged. Education in agriculture and forestry is divided into the highest, the secondary, and the primary instruction. The first is represented by the Superior School of Agriculture in Vienna, by the agricultural division of the University of Cracow, and by Chairs of Agriculture in the Imperial Schools and Royal Polytechnic Institutes of Vienna and four other cities. The second is afforded in the Schools of Agriculture and Forestry, Horticulture, and Brewing, and in Institutes of Aerology and Pomology. The third is provided in the Practical Schools of Agricul-

ture, Horticulture, Arboriculture, Viticulture, Brewing, and Household Economy. There are several experimental and research institutions, some supported by the State, and others by agricultural associations.

Hungary, from an agricultural point of view, is the more important of the two main divisions of the empire. The latest official return available, that of 1906, put the arable area at 34,587,793 ac., of which 25,157,387 ac. were under corn crops. Permanent grass for hay covered 8,316,149 ac., and pasture 10,127,000 ac. The total under crops and grass, according to an official report issued in 1908, is 53,426,100 ac. Woods and forests take up 22,281,400 ac. Wheat, covering over 9,500,000 ac., is by far the most important of the cereals, and it is followed by maize, with over 6,700,000 ac., while barley, oats, and rye cover 2,766,000 to 2,812,000 ac. each. Wheat has increased in area in the last ten years, chiefly at the expense of rye, and the total extent of corn crops has expanded by about a million acres within that period. Hungary is a wheat-exporting country, though her surplus is mainly required by Austria. For flour of fine quality the former country has long been famous, and Hungarian flour has long been well known in this country. Average yields for five years are 17·80 bus. of wheat per acre, 21·60 of barley, 26·60 of oats, 16·28 of rye, and 20·87 of maize. Potatoes, on about 1,500,000 ac., average 3·15 tons per acre. Mangolds are grown on about 420,000 ac., sugar beet on 235,000, tobacco on 104,000, and hops on about 1400. Vineyards cover over 742,000 ac. The latest returns of live stock are given in round figures in Agricultural Hungary, a handbook issued by the Ministry of Agriculture. The numbers are smaller than those given in the foreign statistics of the British Agricultural Returns, as taken from the 'Annuaire Statistique Hongrois'. In the latter return Croatia and Slavonia are included, and possibly they are not covered by the figures given in the handbook, which makes the numbers 2,000,000 horses, 6,000,000 cattle, 6,600,000 sheep, and 4,500,000 pigs. These are all round figures, and the great variations in the quantities returned at different periods lead to the surmise that these live-stock statistics are very loosely collected. The number of goats, not given in the handbook, appears to be about 309,000.

Much improvement in the breeding of horses and cattle has taken place in recent years, assistance being given by the State. There are several national stud farms, upon which carefully selected stallions and mares are kept; but they appear to be devoted to the production of racing, trotting, and carriage horses rather than to that of heavy animals. The native cattle of the country, although unsurpassed for draught purposes, have given way to a great extent to types more suitable to meat and milk production. The State supports the improved breeding of cattle and the development of dairy farming. Sheep breeding has decreased greatly during the last quarter-century. Merinos are kept chiefly on the great estates, the production of wool being an important consideration; while the Cigája and Racka breeds are kept mainly by the peasant proprietors, who commonly milk the ewes in order to sell the milk or to convert it into cheese. It is estimated that two-thirds of the ewes are milked. The principal native breed of pigs is the Maugalier, an excellent type of animal, as represented by an illustration in the handbook. Recently, however, Yorkshire pigs have been largely imported by the Government, in order to improve the bacon-producing qualities of the native animals.

Hungary is a great poultry and egg producing country, but only recently have the types of chickens, ducks, and geese been improved by importing breeding birds from England and other countries.

The production of wine and beer are very important undertakings in the country, and fruit and culinary vegetables are extensively grown for home use and export. These and all other branches of agriculture and horticulture are assisted by the State, every effort being made to advance their efficiency and profitableness. Forestry likewise receives full consideration, while assistance is also given towards the maintenance and extension of agricultural co-operation and credit banks, and the condition of the farm labourers is not neglected by the Ministry of Agriculture.

Similarly the system of agricultural education, experiments, and research is a very comprehensive one, covering all the branches of agriculture, horticulture, and forestry alluded to in the preceding remarks; also representing all grades of instruction, from the most elementary to the highest. Perhaps there is no other country in the world in which what is called the 'paternal' system of State assistance to agriculture is carried out as comprehensively and in as much detail as it is in Hungary, largely, however, through the agency of local authorities and associations.

Belgium.—This little country is pre-eminently one of intensive farming, which is rendered advantageous by the dense population and the minute subdivision of the soil. The total area under crops and grass returned in 1906 was 4,362,766 ac., of which 1,846,681 ac. were in grain crops. Rye and oats are the cereals most extensively grown. The former generally leads; but in 1906 there were 645,223 ac. under oats, and 624,685 under rye, followed by 370,680 for wheat, and much smaller areas for barley, beans, peas, spelt, and buckwheat. Potatoes covered the relatively high proportion of 357,856 ac., and turnips nearly as much, while mangolds and sugar beet are usually about equally grown on areas ranging a little above or below 150,000 ac. Clovers and kindred leguminous crops are extensively cultivated for stock-feeding and hay, over 400,000 ac. being returned for lucerne, sainfoin, trifolium, and 'other clovers'. The extent of permanent pasture in 1906 was 1,155,380 ac. As a fruit-growing country Belgium's position is indicated by the return of 157,000 ac. under orchards. Other crops are flax, hops, tobacco, chicory, and colza.

Belgium is one of the very few countries credited with higher yields per acre than those

of Great Britain for certain crops. There is possibly some question as to the accuracy of averages derived from statements as to the yields of a vast number of small plots of the several crops; but the official returns of countries can only be taken as they are presented, and the working-out of areas and total quantities of produce for four recent years bring out the following quantities per acre in bushels for the principal cereals: Wheat, 27·43; barley, 48·91; oats, 54·95; rye, 31·70. There is nothing remarkable in the figures for wheat and rye; but those for barley and oats are extraordinary. Another high average is 6·77 tons per acre for potatoes, while 18·06 tons may be considered fair for mangolds, 12 tons not very good for sugar beet, and an average of about 9 tons for turnips very low but for the fact that this root is largely grown as a second crop in a season. For live stock the latest figures are 1,779,678 cattle, 1,148,083 pigs, and 244,893 horses. There are no recent returns for sheep and goats, about equally kept on a small scale. The numbers of cattle and pigs are very large in proportion to the area under crops and grass.

Belgium was one of the first countries to give attention to agricultural education, some instruction of the kind having been given in rural schools as early as 1849, though it was some years before any approach to a system was initiated. That system has now become a comprehensive and elaborate one, covering all branches of agriculture and horticulture and providing for a gradation from the most elementary to the highest course of instruction. The schools and courses of instruction are attended by a great number of pupils, and, according to a recent report presented by the Minister of Agriculture, the results are shown in a great improvement in the cultivation of the soil and the live-stock industry. Through the agency of local bodies, the State makes great and comprehensive efforts to promote agricultural and horticultural prosperity.

Belgium is a considerable exporter of fresh pork and rabbits, eggs and poultry, to this country. From that country also we receive somewhat large quantities of flax, beet sugar, outdoor and hothouse fruit, potatoes, hops, and seeds.

Bulgaria.—The cultivated area of Bulgaria is small in proportion to the total area—only 6,380,954 ac. out of 23,797,000, according to the latest available return, that of 1903. But the agricultural statistics of the country are not up to date, and no reliance can be placed upon the figures as representing present areas of crops. Corn crops are returned as covering about five-sixths of the area under crops and grass, over two million acres of wheat and half as much maize being usually grown, while barley occupies over half a million acres. Rice, colza, tobacco, flax, and hemp are other crops. Vineyards cover about a quarter of a million acres, and the trade in grapes and wine is important. The plum crop also is one of some importance, while the production of roses, partly for sale as such, but mainly for the manufacture of perfume, is on a scale equalled in few if in any other countries. Sericulture gives occupation to a large number of persons, silk cocoons being exported in considerable quantity. In cereal years following productive harvests we import moderate quantities of grain from Bulgaria. Cattle, sheep, goats, and poultry are extensively kept in the country, and eggs figure among the exports.

Denmark. See art. Denmark, Agriculture of.

England. See art. England, Agriculture of.

France.—For variety in the products of the soil, the breeds of live stock, including poultry, and the products of the dairy, France is the most interesting country in the world. This is mainly owing to diversity of climate, but partly also to the 'infinite capacity of taking trouble' exhibited in some branches of agricultural industry. Climate has most to do with the production of the finest and most numerous varieties of wine produced in any country, and with the growing of choice fruits; but the superiority of France as the producer of the most numerous and excellent varieties of soft cheese, and the fact that French market gardeners, particularly in the neighbourhood of Paris, pursue a more intense system of culture than is practised in any other country, must be attributed to pre-eminent industry and caretaking.

The north and north-west, and to a smaller extent the central provinces, are the great corn-producing divisions, particularly as respects wheat and barley. Oats are more widely grown on a large scale, though still most extensively in the north, north-west, and centre; while rye is produced largely also on the poorer soils more to the south. Potatoes are grown more or less in all parts of the country; but the early crop, much of which is exported to this country, is mainly produced in Brittany. Normandy is a great province for pastures, and stands first in reference to the dairy industry, some of the choicest butter and soft cheese in the world being produced there. It is also a great apple-growing and cider-producing province. The vineyards, apart from the Champagne district, lie south of the latitude of Paris, being most extensive in the south, although of considerable importance in parts of the east and south-east also. Olives, mulberry trees for sericulture, certain subtropical fruits and nuts, outdoor peaches, and apricots are also products of the sunny south, as also are maize and a small quantity of rice. Sugar beet is grown over a large extent of the country, but mainly in the north; tobacco also in many divisions, but chiefly in the south-west. Hemp, flax, and oil-seeds are among the other products of the country.

With respect to breeds of cattle, the number, so far as names determine it, is very large, as each of a great many districts gives its name to its cattle, however little they differ from those of other districts. According to Mr. Richardson, the author of The Corn and Cattle Producing Districts of France (Cassell & Co.), there are fifteen acknowledged races, of which the others are merely offshoots. The Charolais, Salers, Maine, Femeline, Breton, Parthenay,

Limousin, and the Flemish are among the best known. The Nivernais, which figures at French shows, is really a cross between the Charolais and the Shorthorn. The latter has been used for the production of other so-called breeds. Swiss and English cattle are also kept to some extent in France.

The Merino is the most important of the French breeds of sheep, and that, of course, was originally an imported one. The more ancient breeds of the country, as a rule, are inferior animals, although some of them have been greatly improved by crossing with the Leicester, Kent, Southdown, or some other English breed. Some of the breeds of pigs have the making of good bacon-producing animals in them, with proper attention to breeding. The breeds of poultry are numerous, and many of them are excellent.

More than half the cultivated area of France is farmed by its owners. The latest statistics on this subject, the Minister of Agriculture states in reply to enquiry, are those of a special enquiry made in 1892, but not published before 1898. The number of holdings returned as on the cultivated area of 85,758,700 ac. was 5,618,317, the average size of a holding being 15·26 ac. Of this total, 4,190,795 holdings were farmed by the owners, their area being 45,261,200 ac., or an average of 10·8 ac. per holding; 1,078,184, covering 31,193,100 ac., were farmed by ordinary rent-paying tenants, the average size of a holding being 28·93 ac.; and 349,338, covering 9,304,400 ac., averaging 26·63 ac. per holding, were farmed on the *métayage* system — by tenants sharing returns with their landlords. These figures show that in 1892 about 75 per cent of all the holdings were farmed by the owners, 19 per cent by ordinary rent-paying tenants, and 6 per cent by métayers. A strong contrast is shown by comparing these percentages with those of the 520,000 agricultural holdings returned for Great Britain three years later than the date of the French special enquiry. The return for Great Britain showed that only 11·7 per cent of the holdings were entirely owned by their cultivators, while 3·8 per cent were partly owned and partly tenanted, and 84·5 per cent were occupied by tenants. There is probably a discrepancy in this comparison, arising from the fact that in the British return no piece of land that does not exceed one acre is taken as an agricultural holding, whereas it may be that the smallest patch of cultivated land is included in the French return. But, if the two returns may be regarded as approximately parallel, the average size of an owned or partly owned holding in Great Britain is 58 ac., against less than 11 ac. in France.

Another table in the French return shows that the number of holdings given above as held by owners is considerably greater than the number of owners, thus indicating that more than one holding in many cases belongs to the same person. Out of a total of 6,647,044 persons engaged in agricultural pursuits, 2,199,220 were exclusively proprietors, farming their lands themselves or by means of bailiffs, while 1,188,025 cultivated land of their own, but also farmed or worked on the land of others as tenants or labourers. This makes the total number of landowners 3,387,245, as compared with 4,190,795 holdings farmed by the owners.

A third table classifies holdings independently of ownership or tenancy, including in the area the large extent of woodlands and uncultivated land. In this case the number of holdings is put at 5,702,752, as compared with the 5,618,317 already referred to as the number on the cultivated area. Of this number, 2,235,405 were returned as under 2½ ac., 1,829,259 as between 2½ and 12½ ac., 788,299 as between 12½ and 25 ac., 711,118 as between 25 and 100 ac., and only 138,671 as 100 ac. or more. These figures give a striking idea of the extent of the *petite culture* in France; but all the returns together fail to show the number of peasant proprietors in the country, or, in other words, the number of owners of land under any given limit of area. A great mistake has often been made by taking the number of pieces of land under a certain limit on which taxes are paid as representing the number of owners, whereas two or more of the tracts of land are often owned by the same person. Another popular error is to the effect that the system of *petite culture* succeeds in all parts of France. In his Pleasant Land of France (Murray), Mr. Rowland E. Prothero points out that the system succeeds as a rule only where there are advantages as to fertility of soil or proximity to good markets for the sale of the products of farming, dairying, and gardening.

Corn crops in 1906 covered 33,299,191 ac.; potatoes, 3,736,949; mangolds, 1,459,525; sugar beet, 545,986; cabbages, 408,857; clover, lucerne, and sainfoin, over 7,418,000; vetches and various other forage crops, 1,660,260; vineyards in bearing, 4,318,252; temporary grasses and mixtures of seeds, 614,845, and permanent grass, including rough grazings, 24,085,513. Wheat is by far the most important of the cereals. In the year named above, it occupied 16,096,392 ac.; while oats, which came next, covered 9,521,578 ac.; rye, 3,093,774; barley, 1,752,050; maize, 1,154,416; buckwheat, 1,256,857; millet, 56,882; and mixed corn, 367,242. Various pulse crops, some for sale in a green state, given apart from the other corn crops, occupied 781,157 ac. Among the minor crops were 68,602 ac. of colza, 14,479 of rape, 67,972 of flax, 46,799 of hemp, 40,407 of tobacco, and 7546 of hops. For some of the more important crops, preliminary estimates of acreage are available for a later date; but it is desirable to give all for the same year.

France is practically self-supporting in respect of wheat production, the small imports, chiefly required by millers for mixing with native grain, being about balanced by exports of grain and flour in an average of seasons. Since 1894 the wheat grower has been protected by the high duty of 12*s.* 2*d.* per qr. of 8 bus., and the production of wheat in France has been well maintained or slightly increased, in spite of a small reduction in the area of the crop. Previously to 1885, when a duty of 5*s.* 2*d.* per qr. was imposed, there had been only a nominal duty of 1*s.* 0½*d.* In 1887 there was an advance to 8*s.* 8½*d.*, and in 1894 to 12*s.* 2*d.*, as already stated. In the last ten years the acreage of wheat has

ranged from a little over 16,000,000 to about as much over 17,000,000 ac. Previously the area for many years had been usually over the latter extent. The production has ranged in round figures from 37,000,000 to 47,000,000 qr., the latter quantity, the greatest on record, being the produce of 1907. The average production of the ten years ending with 1907 was about 42,000,000 qr., or some half-million less than the mean annual home consumption for that period. Imports since 1884 have been much smaller than they were before that time. Evidence of the steady improvement that has taken place in French farming is to be seen in the following statement of decennial average yields of wheat per acre in bushels, beginning with 1831–40: 14·22, 15·24, 15·71, 15·91, 16·26, 17·43, 18·03, and (eight years to 1908) 19·92. The most striking increases are those of the periods after 1880.

Other recent average yields for ten years are 21·99 bus. per acre for barley, 26·19 bus. for oats, 3·26 tons for potatoes, 10·04 tons for mangolds, 8·99 cwt. for hops, 29·40 cwt. for hay from clovers and temporary grasses, and 28·15 cwt. for permanent grass hay.

The numbers of the several divisions of live stock in France as returned for 1906 are 13,968,014 cattle, 17,461,397 sheep, 1,456,866 goats, 7,049,012 pigs, 3,165,025 horses, 361,856 asses, and 195,297 mules. Cattle, horses, and pigs have increased considerably since 1875, while sheep have greatly fallen off. The number of horses is not limited to those on farms, but includes those kept in Paris.

State aid to agriculture in France is on a very elaborate scale. The agricultural budget for 1907 amounted to £1,808,646, including the large sums devoted to the State forests and horse-breeding establishments. As early as 1839 France had a Ministry of Agriculture attached to that of Commerce, and a separation took place in 1881. The system of agricultural education is very complete. The foundations of it were laid in 1848, when the national schools of agriculture were established, and gradually a very elaborate system has been developed. The fees in the more popular schools are very low, and in the farm schools the pupils work on the land in return for free education.

Grants to encourage improved stock-breeding, the cultivation of flax and hemp, and improvements of various kinds, and to relieve distress arising from inundations or crop failures are liberally given by the Government.

Co-operation, by means of the *syndicats agricoles*, credit banks, and mutual live-stock insurance societies, is in operation very extensively in all parts of the country, and there is no doubt that it has had much to do with the comparative prosperity of farming in France.

GERMANY.—In no country has agriculture improved more strikingly during the last quarter-century than it has in Germany. Always foremost in agricultural science, and among the first in agricultural education suitable to farmers, this country has applied science to practice to an extent which has given highly satisfactory results. Apart from the very high duties levied upon imported farm products, with the avowed object of protecting the cultivators of the soil, the State and local authorities have long made comprehensive efforts, and have devoted liberal grants, to promote agricultural prosperity.

Peasant proprietors are very numerous, and their holdings are generally small in some divisions of the empire, while in others large or medium farms cover a large proportion of the acreage. In Bavaria, for example, according to a very interesting report on Agriculture in Germany, written for our Foreign Office by Dr. F. P. Koenig, a very high authority, farms of less than 2½ ac. occupy 25·5 per cent of the agricultural area; holdings of 2½ to 25 ac., 51·5 per cent; those of 25 to 250 ac., 19·3 per cent; and farms over 250 ac., only 0·1 per cent. But, even in this State, excessive subdivision is prevented by family arrangements, and the smallest holders earn money by working on the larger farms. In Würtemberg, again, 84 per cent of the land belongs to peasant proprietors, and about one-fourth of this area is held by men owning 5 to 13 ac. each, while twice as much is in the hands of owners of over 13 and under 50 ac., and the rest is held by owners of 50 to 125 ac. The rest of the agricultural land, 16 per cent of the total, belongs to the Crown and the nobles. In Westphalia, on the other hand, the majority of the holdings range from 40 to 250 ac., and exceptionally up to 1000 ac., though there are also many holdings of 10 to 25 ac. About one-third of the population of Germany are directly dependent upon agriculture for a living; and nearly 40 per cent of these were actually working on farms at the date of the last special enquiry. About 86 per cent of the agricultural land is held by owners, and only about 14 per cent by tenants.

Dr. Koenig is emphatic in testifying to the improvement that has taken place in German agriculture, and he is confirmed in this opinion by Consul-general Schwabach, of Berlin, a report by whom was issued by the Foreign Office in 1906. The latter states that the acreage of the several crops has altered very slightly during the last twenty years. Comparing averages of acreage and yield for the two quinquennial periods, 1893–8 and 1899–1904, he puts the increase in the area of the white straw crops at 1·56 per cent, and that of the yield at 12·86 per cent.

Rye is the principal breadstuff of the masses of the people, and this cereal is by far the most extensively cultivated corn crop. In 1906 there were 15,070,875 ac. under rye, 10,427,187 under oats, 4,781,903 under wheat, and 4,061,962 under barley. Pulse, buckwheat, and mixed grain, for which figures are not available for 1906, brought the corn area up to about 38,000,000 ac. For some crops, however, details are given only in census years, of which 1900 was the latest. Other important areas returned for 1906 are 8,155,942 ac. of potatoes, 5,124,497 of clovers, 594,872 of lucerne, and 14,600,191 of grass hay. In 1900 there were 1,230,539 ac. of mangolds, over 500,000 of swedes, 1,138,522 of sugar beet, 296,086 of vineyards, 83,145 of flax, 8736 of hemp, 39,231 of tobacco, 93,583 of hops, and over 3,000,000 of bare fallow. The total arable

land covered 65,189,532 ac.; permanent grass, including what was cut for hay and rough grazings, 21,374,639 ac.; and woods and forests, 34,569,794 ac. Recent averages of yield for five years are 28·25 bus. per acre for wheat, 32·83 for barley, 39·69 for oats, 22·33 for rye, 5·17 tons for potatoes, 8·40 tons for mangolds, 4·2 cwt. for hops, 34·22 cwt. for hay from clovers and temporary grasses, and 31·99 cwt. for hay from permanent grass. Oats, flour, eggs, and hops are exported to this country, as well as much beet sugar.

The latest figures available for live stock are those of 1904, when the return was 19,331,568 cattle, 7,907,173 sheep, 3,329,881 goats, 18,920,666 pigs, and 4,267,403 horses. In 1900 there were 7200 asses and 650 mules. Cattle, pigs, and horses have greatly increased since 1897, while sheep have fallen off. Since 1873 the number of sheep fell from nearly 25,000,000 to the number given above for 1904.

Among the breeds of cattle extensively bred are the Breitenburger, East Frisian, Allgäuer, Scheinfelder, Dutch, and the Swiss Simmenthal. There are also many Shorthorns, Galloways, Ayrshires, and other British breeds, used chiefly for crossing with native cattle. The sheep are chiefly Merinos, and that breed crossed with Shropshire, Hampshire, or Oxford Down rams, or with native breeds. Yorkshire pigs are extensively kept, either pure or crossed with native breeds. Hanoverian, Oldenburg, Holstein, Belgian, and Norman horses are largely used for farm work.

Agricultural education is of very old date in Germany, the first agricultural school having been founded in 1802, according to Dr. Rose, H.M. Consul at Stuttgart. This writer divides the system into three grades—advanced, secondary, and elementary. In the first he names the agricultural high schools, agricultural institutes at the universities, other institutes, and special lecture courses for advanced students of the classes of landowners, managers, and farmers. In the next grade are agricultural schools; and in the third, farming, winter, special lower, and rural improvement schools, and special courses of lectures. Three high schools, 8 institutes, 22 agricultural schools, 45 farming schools, 195 winter schools, 243 special schools, and 1079 rural improvement schools are enumerated.

Agricultural co-operation is in very extensive operation, and mutual insurance associations are numerous. As for agricultural credit banks, they are more common in Germany than in any other country. The directions in which the National and Provincial Governments assist agriculture, through the Chambers of Agriculture and otherwise, are very numerous. As in France, agriculture is regarded by the rulers in Germany as the backbone of national prosperity.

GREECE.—Agriculture in this country, apart from the cultivation of the vineyards, is in a very backward condition, although in some parts of the country improvement has made some progress in recent years. Consul MacDonell, in a report on Central Greece for 1906, attributes this backwardness chiefly to the insecurity of property and even life, malaria, the lack of agricultural banks, the smallness of the holdings, and the neglect of proprietors, village communities, and the State to institute works for the common good. Although the plains of Central Greece are exceptionally fertile and well adapted to the production of corn crops, he adds, the production is little more than half what it might be. Almost the only implements and tools in common use are the plough, the hoe, and the reaping hook. The smallness of holdings is against the use of labour-saving implements and machinery, and the small size of draught animals renders it necessary to have implements of the lightest description. Even farmyard manure is rarely put on the land, and artificial fertilizers are hardly ever used. The system of bare fallow is chiefly relied on for the renovation of soil fertility. The rearing of sheep, goats, and pigs is pursued with some success. The native sheep are hardy, and good milkers. Their milk is partly used for making cheese and butter. The vineyards, for the production of wine and dried currants, form by far the most important division of the agricultural land, and currants are by far the chief exports. Other crops of some importance are olives and tobacco, while cotton is grown in at least one district. Only about 750,000 qr. of wheat are usually produced, and the average imports are about the same in quantity. The imports of animals and their products, including poultry and dairy produce, considerably exceed the corresponding exports.

IRELAND. See art. IRELAND, AGRICULTURE OF.

ITALY.—Land tenure in this country exists in various forms. The three main divisions are those of ownership, tenancy similar to that of Great Britain except for certain contributions of capital by the landlords, and the *mezzadria* or *métayage* system under numerous modifications as to the supply of capital and the division of products or profits. Peasant proprietors and other cultivating owners of land on farms of various sizes abound throughout the country, while other forms of land tenure respectively prevail more or less extensively in different provinces or districts.

The climate of Italy, like that of France, allows of the cultivation of a great variety of crops. The agricultural statistics of the country leave much to be desired. Complete figures are published only at wide intervals, and even those relating to the most important crops appear tardily, excepting the estimated production of the grain crops. The latest complete figures available for the foreign section of the British Agricultural Returns are those of 1895, while the areas of only six crops are given for one later than 1903, and yields only up to 1905. Moreover it is stated that most of the quantities are only approximate. The area of all the crops enumerated for 1895 is 51,881,000 ac., of which 20,921,000 ac. are credited to corn crops, 516,000 to potatoes, 128,000 to flax, 259,000 to hemp, 12,955 to tobacco, 8,551,000 to vineyards, 2,554,000 to olives, 1,018,000 to chestnuts, 4,179,000 to clover, &c., and 13,743,000 to meadows and pastures. The list is obviously incomplete, as it

does not include the acreage of sugar beet and various forage crops. In an official report a few years ago the total cultivated area was put at 60,000,000 ac. The sugar-beet industry is a very important one. Woods and forests cover over 10,000,000 ac. Wheat in 1895 covered more than half of the corn area, while in 1903 it reached nearly 12,000,000 ac. Maize is grown on between 4,000,000 and 5,000,000 ac., the oat crop on over a million acres, barley on less than three-quarters of a million, rye on about 338,000, rice on 403,000, and pulse of various kinds on over 2,000,000. Approximate estimates of the yields of crops per acre are 13·20 bus. of wheat, 10·60 of barley, 15·65 of oats, 19 of maize, and 11·97 of rye. Much of the land, apart from the rich plains of the north, is naturally poor, and, although considerable improvement in the agriculture of Italy has taken place in the last thirty years, the great majority of the cultivators of the soil are too poor to farm well, while the produce or profit-sharing system is not conducive to enterprise. The extent of vineyards in Italy is greater than that of any other country in the world, being double that of France; while olives are more largely produced than in any other European country. Great losses on what the money returns from grapes and olives might be, are incurred through primitive and wasteful methods of preparing the wine of the former and the oil of the latter. Fruit of various kinds, not covered by the agricultural statistics, is produced, and sericulture is an important branch of the agricultural industry.

The numbers of the several classes of live stock returned for 1905 are 5,672,000 cattle, 10,877,000 sheep and goats, 2,224,000 pigs, 804,913 horses, and 341,910 mules. Judging from earlier returns, the sheep may be put at about 8,600,000, and the goats at 2,277,000. The Parmesan, Piedmontese, Modenese, and Chianina cattle are the best for beef; while the cows of Brescia and Belluna are excellent for milk, and the Romagna and Maremma breeds are in high repute for draught purposes, as well as the cattle of Apulia. Sheep-farming is most extensive in Latium, the Abruzzi, Apulia, Basilicata, Calabria, and Sardinia. In some parts of the country the native breeds have been improved by crossing them with Merinos, and in others by mating the ewes with rams of British breeds. Similarly the pigs in many districts have been crossed with Yorkshires or Berkshires.

The dairy industry of Italy is of great importance, its products being valued at nearly £5,000,000 per annum. Cheese, eggs, butter, hemp, &c., sent to Britain. Dairy farming is carried on largely under the stall-feeding system in Lombardy; but generally in the rest of the country the cows are grazed on the mountain sides in summer, and in the plains and valleys in winter. The manufacture of Parmesan, Gorgonzola, Emmenthal, and other varieties of cheese absorbs much of the milk, while butter also is produced on a considerable scale.

Agricultural education has made much progress in Italy during the last twenty years. According to an official report obligingly sent by the Intelligence Branch of the Board of Agriculture, the higher agricultural education is provided for by five superior schools of agriculture; while for the secondary education there is an unstated number of technical schools of agriculture, viticulture, horticulture, arboriculture, zoology, and dairying; and for the lower division there are practical and free schools, and migratory classes. Experiment stations and laboratories are numerous.

Agricultural co-operation and loan banks have made much headway in most parts of Italy, greatly to the advantage of the small cultivators. The condition of farm labourers who have no land, in spite of some improvement, is generally wretched, and emigration is extensive.

THE NETHERLANDS. — The fertility of this country is mainly due to the industry and enterprise of its cultivators. Much of the richest land has been reclaimed from the sea or from marshes, while there is a great expanse of sandy soil in the interior. Dutch agriculture is largely devoted to the production of culinary vegetables, flowers, fruit, nursery stock, fibrous and other industrial plants, seeds, and roots and other forage crops for the important live-stock and dairy industries. The total area of the country, apart from lakes and rivers, is only 8,038,000 ac., and of this quantity 633,775 ac. were covered in 1906 with woods and forests, while waste land made up much of the rest of the difference between the total area and the 5,266,966 ac. under crops and grass. Corn crops in the year named covered 1,290,469 ac., while 397,952 ac. were devoted to potatoes, 7390 to onions, 182,069 to orchards and nursery grounds, 104,706 to sugar beet, 38,194 to flax, 23,961 to other industrial plants, 80,547 to roots and similar forage crops, in addition to 238,469 ac. grown as second crops after other crops in the same season, 150,522 to clover, lucerne, and rotation grasses, and 2,959,074 to permanent grass for hay and grazing together. Small areas are entered in the official returns for chicory, colza, tobacco, and hops. Of the corn area only 140,286 ac. were devoted to wheat, rye on 539,003 ac. being the cereal most extensively grown, followed by oats, with 343,654 ac. Other corn crops were 70,805 ac. of barley, 669 of spelt, 47,837 of buckwheat, 75,740 of beans, and 72,475 of peas.

Average yields for a recent period of five years were 29·82 bus. per acre of wheat, 46·06 of barley, 52·85 of oats, 24·97 of rye, 5·54 tons of potatoes, 12·58 tons of sugar beet, and 10·99 cwt. of hops. The averages for barley and oats are much higher than those of Great Britain, a favourable comparison very uncommon among the countries of the world.

The latest available return of live stock is that of 1904, for which year the enumeration was 1,690,463 cattle (973,098 being cows), 606,785 sheep, 165,497 goats, 861,840 pigs, and 295,277 horses. Cattle had increased considerably since 1890, pigs by nearly 300,000, and horses by about 22,000, while goats had remained nearly stationary in number, and a decrease of over 200,000 sheep was shown. Dutch cows are noted for their heavy milking capacity, quantity rather than quality being characteristic of the milk and other dairy products of the Netherlands.

Holstein cows are exported to many countries, as also are the heavy draught horses for which the country is famous. The exports of cheese, condensed milk, butter, and beet sugar are on a large scale. In 1907, Holland stood second among the countries sending cheese to this country, the quantity being 241,553 cwt. The quantity of butter which we imported from the same source in 1907 was 168,496 cwt., while two years earlier it was nearly 210,000 cwt. Moreover, all but an insignificant proportion of the margarine which we import under its proper name comes from the Netherlands, over a million hundredweights having been sent to us from that country in 1905 and 1906, and 836,658 cwt. in 1907. Bulbs and various flowers, as well as nursery stock, are important Dutch exports; also fruit, fibrous plants, and seeds.

According to a report issued a few years ago, 85 per cent of the farms in the Netherlands are under 50 ac., the average size of a farm being about 30 ac. About 42 per cent of the holdings are farmed by tenants, and 58 per cent by the owners.

The amount of money voted by the Central Government for application by the Department of Agriculture in 1907 was £177,630, and the local governments give additional assistance to the agricultural industry. The educational institutions are the High School of Agriculture, Horticulture, and Forestry at Wageningen; the Veterinary High School at Utrecht; thirteen agricultural, horticultural, and winter schools; and a great number of winter courses of instruction.

NORWAY. — Few countries have so large a proportion of waste land as Norway possesses. Agricultural statistics are collected only decennially, and out of a total area of 76,717,000 ac., exclusive of lakes, only 2,272,400 ac. were under crops, exclusive of grass, in 1900, while 57,048,849 ac. were entered as permanent grass, marsh, and uncultivated land, and 6,845,000 ac. as woods and forests. Only a little over 400,000 ac. were devoted to corn crops, more than half being occupied by oats, while sown grasses covered 1,705,041 ac., and other green forage crops, apart from turnips, 21,901 ac. Apart from 90,661 ac. of potatoes and the small acreage under corn crops, it will be seen, the agricultural area of the country is devoted almost entirely to food for live stock. Yet the number of cattle fell from 1,417,524 in 1890 to 950,201 in 1900, that of sheep from 1,417,524 to 998,819, that of goats from 272,458 to 214,594, and that of reindeer from 170,154 to 108,784. Pigs increased from 121,057 to 165,348, and horses from 150,898 to 172,999. Dairy farming is the most important branch of agriculture, 689,563 out of the 950,201 cattle returned in 1900 having been cows. Yet these animals had fallen off in number from 706,925 in 1890.

State assistance to the extent of £51,745 was given to agriculture in Norway in the last financial year, including salaries to officials. The local authorities also contribute funds towards agricultural education and for other purposes. Grants are given to agricultural, show, and breeding societies, and to the dairy industry. There is one agricultural college, and eighteen agricultural and dairy schools were enumerated in the latest report on the subject. There are also some milk control stations and some chemical control associations.

PORTUGAL.—There are no systematic or regular agricultural statistics for this country, and therefore the distribution of land to the various crops cannot be given. In a report issued a few years ago by the Portuguese Minister of Public Works it was stated that the average area of wheat was about 771,000 ac., or about one-fourth of the total cultivated area, while rye was grown on 823,000 ac., and maize on 679,000. These cereals, with barley, oats, flax, and hemp, are grown extensively in northern Portugal, and on high ground in most of the rest of the country. Vineyards also are extensive on the uplands in all parts of the country, while olives, oranges, lemons, citrons, figs, almonds, pineapples, and rice are produced largely on the lower levels, chiefly in the centre and south. Onions and potatoes are produced and exported in great quantities, while garlic and tomatoes are important crops. Apples and other hardy fruits are also produced on a considerable scale. Probably the most important single industry is the cultivation of the vine, grapes and wine being exported extensively. Olives are consumed freely, but in a riper condition than that of those which are exported, by the masses of the people, and they appear to be grown more or less in all districts.

Cattle and pigs are bred on an extensive scale, and sheep less generally. Years ago, when we imported cattle from the Continent of Europe, the Portuguese beasts were among the finest and best that we received. They are used for draught purposes more or less. The draught horses are generally small, but big enough to draw the light native ploughs and other implements.

The agriculture of Portugal is mainly in a primitive condition, and yet the farmers, particularly in northern Portugal, are in easy circumstances, though they and their women folks work hard on the land. The northern farmers to a great extent enjoy very favourable conditions of land tenure, somewhat similar to those of copyholders in this country, as they pay only a low quit-rent for the land they cultivate, and they have fixity of tenure. In an interesting book, Portugal Old and New (Kegan Paul & Co.), written some years ago by Mr. Oswald Crawford, at that time British Consul at Oporto, it is stated that the land throughout the length and breadth of the country is held under five principal kinds of tenure—the allodial, the emphyteutic, the leasehold, the communal, and the *Parceria rural*, which is similar to the métayage system. The allodial tenure prevails mainly in the fertile plains of central and southern Portugal, the owner of the land either cultivating it himself, or letting it for money rents to tenants; and the métayage system is more common in the same divisions of the country than in the north. The communal system exists chiefly in the wild and mountainous districts, while the emphyteutic system, as already intimated, is prevalent in

the north, the most prosperous division of the country. There wheat is grown after wheat, and maize after maize, and yet good crops are produced. The explanation is, that all the straw is used as food for stock; gorse, heather, fennel, leaves, wild grasses, and other plants being collected for litter. Seaweed and shellfish are used for manure near the coast. Irrigation is commonly practised, and this is in no small measure accountable for the comparatively large production of the crops.

ROUMANIA.—This fertile country is mainly cultivated by peasant proprietors. Its farming consists chiefly in the production of cereals and live stock, no less than 13,171,659 ac. out of 15,243,798 ac. cropped in 1906 having been under corn crops. The latter quantity does not include grass land grazed, the area of which is not given in the official returns. The figures for 1906 are taken in preference to those of 1907, as better representative of average years. For some unaccountable reason the total acreage under cultivation in 1907 is represented as about 1,300,000 ac. less than in 1906, either through an error, or because much of the land was left uncropped in the very unfavourable season of 1907, and there is no entry for fallowed land. In 1906 Roumania had 4,996,422 ac. under wheat, 5,142,308 under maize, 1,379,989 under barley, and 943,328 under oats, with smaller areas of rye, millet, buckwheat, and pulse. Potatoes covered 27,138 ac.; colza, 75,550; flax, 58,144; hemp, 10,021; vineyards, 215,231; sugar beet, 23,900; tobacco, 15,428; plums, 176,975; market gardens, 74,490; grasses under rotation, 174,044; and permanent grass for hay, 1,217,357. Roumania is a great exporter of wheat and maize. Great quantities of the latter and also of wheat and barley come to Britain.

Live stock are enumerated only in census years. The returns in 1900 were 2,588,526 cattle, 5,655,444 sheep, 232,515 goats, 1,709,205 pigs, 864,324 horses, and 7701 mules and asses.

There is much need of improvement in Roumanian farming, as the average yields of corn are far below what they should be in a naturally fertile country. Averages for some recent years were only 15 bus. per acre of wheat, 14·64 of barley, 21·09 of oats, 13·86 of rye, and 16 of maize.

RUSSIA.—It is obvious that the agriculture of the immense Russian empire, extending from the Baltic to the Pacific Ocean, and from Germany to China, cannot be described fully in the section of an article. Yet, while the vast empire borders upon the Arctic regions in the north and contains semi-tropical regions in the south, so that Icelandic lichen is the food of the reindeer in Lapland, while the olive and the tea plant are grown in the Caucasus, and grapes and subtropical fruits in the warm sections of Siberia, the cultivation of cereals is the mainstay of Russian agriculture in all but the semi-Arctic regions, in which there is no agriculture worthy of the name.

Excepting the figures relating to the cereals, potatoes, and grass meadows for hay, Russian agricultural statistics are irregularly issued, even in reference to production, while those of areas are often two years or more behind the figures relating to yield. In European Russia, exclusive of Poland, the area under crops is available for no later year than 1901, when it was returned at 310,766,522 out of a total area of 1,244,367,000 ac., exclusive of lakes. The area under woods and forests is given for no more recent date than 1881, when it was 425,564,842 ac. There is no account of the great extent of grazing land. For Poland the total area under crops is returned for 1902 at 17,659,407, while there are no corresponding totals for Caucasia or Siberia and the Steppes. The totals under corn crops are returned for 1906 in acres as follows: Russia in Europe proper, 191,581,130; Poland, 11,219,540; Caucasia, 13,900,212; Siberia and the Steppes, 2,433,248; total, 219,134,130. For the whole empire in 1906 the totals are 63,641,699 ac. of wheat, 74,996,515 of rye, 23,822,325 of barley, and 45,370,268 of oats. The areas for maize, millet, buckwheat, and pulse are much smaller. For potatoes the quantity is 10,096,450 ac., all but about 380,000 being grown in European Russia and Poland. The official estimates of yield in round figures, also for 1906, are 63,097,000 qr. of wheat, 77,600,000 of rye, 37,350,000 of barley, 73,500,000 of oats, and 25,500,000 tons of potatoes. Yields per acre are small in the extreme. Averages given for some recent years are only 9·05 bus. of wheat per acre, 11·16 of rye, 11·84 of barley, and 15·67 of oats for Russia in Europe, exclusive of Poland. For Poland the figures in the same order are 14·70, 12·33, 17·13, and 17·41; for Caucasia, 10·28, 10·88, 15·69, and 17·95; for Siberia and the Steppes, 10·06, 9·52, 13·40, and 14·43. Russia is one of the countries that supply Great Britain with large quantities of wheat, as well as barley and oats.

The total numbers of live stock for the four great divisions in 1907 are 42,704,980 cattle, 58,110,523 sheep and goats, 12,279,153 pigs, and 28,337,552 horses. Cattle, pigs, and horses have increased since 1900, while sheep and goats together have fallen off. The proportion of goats is very small, and probably the decrease is almost entirely that of sheep.

Native races of cattle have been crossed with some British breeds and with the French Charolais, while Merinos have mainly replaced Russian breeds of sheep. English pigs have been imported to improve the native stocks, and to breed separately. For horses, Russian breeders have had recourse chiefly to France, using Percheron, Norman, and Ardennes horses for breeding pure or for crossing with native animals.

Dairy farming has been vastly expanded and much improved within the last ten or fifteen years, particularly in Finland. Russia stands next to Denmark in butter exports to this country. Poultry keeping is also an important industry, Russia being the largest contributor of poultry, and by far the largest of eggs to our foreign supplies.

Modern implements and machinery are used on the great estates; but the tillage of the peasants is of a wretched description as a rule. They own the land they cultivate, excepting

those who work entirely upon the large farms, and most of these have a little land; but a large proportion of the land is farmed in common by village communities, and this system is antagonistic to improvement. A strong movement has sprung up recently in favour of the acquisition by the peasants of individual ownership, and this is helped by the State banks. The taxation of the land is extremely heavy in relation to the poverty of the peasant cultivators.

Viticulture is being developed greatly, particularly in the Caucasus, and sericulture gives employment to a large number of people. The beet-sugar industry is also being advanced steadily, as also is the cultivation of the tea plant. Agricultural education under the Board of Agriculture is carried out on a scale very small in proportion to the vastness of the empire and the agricultural population. Agricultural banks have been established to some extent by the Government.

SCOTLAND. See art. SCOTLAND, AGRICULTURE OF.

SERVIA. — Like Roumania, Servia is a great corn-growing country, 2,897,038 out of a total cultivated area of 4,233,763 having been under cereals in 1904, the date of the latest available return. But a very important branch of farming is the production of plums and other fruit, to which 373,901 ac. were devoted in the year named. Vineyards are not very extensive, and the cultivation of sugar beet is on a very small scale. Onions, garlic, cabbages, hemp, flax, and tobacco are other crops. Maize is the most important of the cereals, 1,335,998 ac. being under it in 1904. Wheat came next with 905,008 ac. The live stock returned in 1900 were 956,661 cattle, 6929 buffaloes, 3,061,759 sheep, 432,067 goats, 959,580 pigs, 184,849 horses, and 1940 mules and asses. Servia is one of the few countries showing an increase in the number of sheep, at least up to the latest year of enumeration. Agricultural co-operation has made considerable progress in the country.

SPAIN. — Wheat, grapes, and olives are the most important crops in Spain; but there is a great diversity of production, which is not indicated in the meagre agricultural statistics of the country. For example, while the cultivated area was returned in 1906 at 53,606,114 ac., the enumerated crops, apart from 'pasturage of down and meadow land', 59,417,201 ac., amounted to less than 36,000,000 ac., of which over 19,000,000 were returned as under grain and pulse crops, while 3,609,421 ac. were in vineyards, and 3,445,477 ac. were devoted to the cultivation of olives. No entries of fruit, including nuts, which are largely grown, are in the statistics. As the 'pasturage' greatly exceeds the 'cultivated land', it is clear that it is not included, and no entry for hay is given. In 1907 Spain grew wheat on 9,133,875 ac., or nearly half the area devoted to corn crops. The country is nearly self-supporting in respect of wheat when the harvest is a good one. The other principal cereals are returned for 1907 at 2,959,628 ac. of barley, 1,185,958 of oats, 2,227,172 of rye, and 1,109,013 of maize.

Live stock were enumerated for 1906 at 2,497,062 cattle, 13,480,811 sheep, 2,439,635 goats, 2,080,404 pigs, 440,272 horses, 743,991 asses, and 801,608 mules. Cattle are bred largely for draught purposes.

Farming is in a very backward condition in Spain. Apart from the irrigated land, the yields of cereals are extremely small. In a Spanish official report issued some years ago, the averages for four years ending with 1890 were put at only 6·38 bus. of wheat, 15·89 of barley, and 15·85 of oats on unirrigated land, and at 20·52, 21·01, and 24·16 on irrigated land. As the latter forms only a small proportion of the cropped area, it does not affect the general averages to a very great extent. In a table published in the British Agricultural Returns, the yields for four years ending with 1902 were put at 12·70 bus. of wheat, 18·91 of barley, and 16·24 of oats. Except where irrigation, a legacy from the Moors, is general, a crop is grown on the same land only once in either two or three years, chiefly the latter, the land being fallowed during the rest of the time. Comparatively high farming is carried on in Valencia, Alicante, and Barcelona, with some of the Cantabrian provinces; while the practice of husbandry is very poor in the central and some other provinces. In Navarre, Aragon, and the eastern provinces, where irrigation is general, fallows almost entirely disappear, and the farming is comparatively good.

Peasant proprietors are numerous only in the neighbourhood of large towns and on limited areas of specially good land elsewhere. Most of the peasants either work for wages, or hire small farms at money rents or under various modifications of the métayage system. In the autumn of 1907 the Agricultural Department was entirely reorganized, provision being made for a graduated system of agricultural education, experiment stations, seed testing, and the encouragement of improvements.

SWEDEN. — This is a great dairying country, and it is to be observed that a considerable portion of the butter imported into Great Britain and credited to Denmark is of Swedish production; but still the quantity directly consigned to Britain from places in Sweden is large. Most of the farms are small, though larger than in some European countries, and owned by the occupiers, and the success of the agricultural industry, as in Denmark, is largely owing to the thrift of the peasant proprietors, the thoroughly practical system of agricultural education, and the efficiency of the co-operative system which prevails throughout the country.

The crops and grass enumerated in the returns for 1906 amounted to 12,394,917 ac., of which 4,166,085 were in corn, 375,976 in potatoes, 18,107 in roots, including sugar beet, 40,691 in vetches, 5219 in flax and hemp, 104,511 in garden land, and 974,030 in bare fallow. From these figures it will be seen that the farmers rely largely upon hay for the winter feeding of their live stock. The principal cereal crop is that of oats, which covered 2,007,038 ac. in 1906, followed by rye with 1,014,918 ac., barley with 502,635, mixed corn with 368,230, wheat with 211,975, and small areas of beans and peas. The average yields in a recent period of five years

are put at 24 bus. of wheat per ac., 24·40 of barley, 28·98 of oats, 22·35 of rye, and 3·43 tons of potatoes. Much of the land is naturally poor, and the yields could not be expected to be large.

Of the 2,600,151 cattle returned in 1906, no fewer than 1,792,075 were cows. Sheep numbered 1,051,119; goats, 65,285; pigs, 872,363; and horses, 563,554. Cows have increased considerably since 1890, and pigs and horses greatly, while sheep and goats have fallen off in number. The success of the bacon industry accounts for the increase in pigs.

The cultivated proportion of the total area of Sweden, 101,520,000 ac., exclusive of lakes and rivers, is very small. Woods and forests covered 52,734,614 ac. in 1906, and there is a large area of waste land.

State assistance to agriculture covers agricultural, horticultural, veterinary, and dairy education, seed and butter control, and help to agricultural, stock-breeding, and co-operative societies.

SWITZERLAND.—Very small holdings, owned by the cultivators, prevail in this country, and much of the land is very poor. The peasant proprietors are extremely thrifty, their scale of living being very low. If it were not for the great number of tourists who annually visit the country, creating a great demand for dairy produce, meat, vegetables, fruit, poultry, and eggs, a living would not be possible for a family on a large proportion of the minute holdings. Dairying, including the production of condensed milk for export (much of it to Britain), is the most important industry. In 1906 the cultivated area was returned at 5,503,160 ac. There are no details as to the division of farm crops, but a very large proportion must consist of pasture. Vineyards covered 69,207 ac.

The returns of live stock in 1906 were 785,577 cows, 712,327 other cattle, 209,243 sheep, 359,913 goats, 548,355 pigs, 135,091 horses, 1652 asses, and 3136 mules. Cattle and horses have increased since 1896, while sheep, goats, and pigs have decreased. Swiss cows are noted for their milking capacity.

Agriculture, including horticulture, viticulture, sylviculture, and dairying, receives assistance from the Federal Government and the several governments of the cantons, much of the money granted being spent on education.

TURKEY.—There are no agricultural statistics for this country, in which the products of the soil are greatly varied. Corn, grapes, oranges and other subtropical fruits, olives, tobacco, flax, hemp, oil-seeds, wool, and silk are important products of the country. Cereals are extensively exported in seasons of good harvests, including much barley to Britain, besides wheat, oats, and beans from Asiatic Turkey, as also are live stock, skins, and many minor products. The tobacco crop of 1905 was estimated at 39,000 tons. The grapes to a great extent are used for raisins, and other dried fruits are largely exported. Sheep-breeding is an important branch of the live-stock industry. The condition of the cultivators of the soil is seriously impaired by heavy taxation and the oppressive system under which it is levied. It may be hoped, however, that the Constitution recently granted by the Sultan will result in an improvement in this as in many other circumstances affecting the wellbeing of the agricultural population. [W. E. B.]

Evanidæ, a family of parasitic Hymenoptera, with their abdomen attached to the upper part of the metathorax and a straight ovipositor. The larvæ are parasitic on the egg capsules of cockroaches, and in this way have been spread to many new countries. [F. V. T.]

Evaporation. See SOIL, WATER RELATIONSHIPS OF.

Evening Primrose. See ŒNOTHERA.

Evergreens.—This term is applied to all those plants which are never leafless, new leaves being formed before the old leaves have fallen off. In many plants the leaves are persistent for several years, as for example in Coniferæ, but generally plants cast their leaves before they are two years old, as do the Hollies, Laurels, Rhododendrons, Berberis, and Ivy. The plants themselves are evergreen only because of this overlapping, as it were, of the current and previous year's leafage, whereas in what are termed deciduous plants there is a well-marked interval between the fall of the matured leaves and the development of new. Evergreen plants are of great value to man for various purposes, such as shelter from cold, as wind-breaks and screens, and to form permanent features in the garden and landscape. It is astonishing how great a difference a belt of evergreen trees or a hedge of holly or yew or other conifer will make. There are not many evergreens among our native trees and shrubs, but we are fortunate in the possession of a great many that have been introduced from North America, China, Japan, &c. The Coniferæ constitute the most important of these. It is difficult to imagine what our gardens and parks were like before the introduction of the Cedars, Firs, Cypresses, the great Pines and Spruces, the Evergreen Oak, Rhododendrons, Yuccas, Berberis, Cotoneasters, Aucubas, Privets, and Cherry and Portugal Laurels. Most evergreens object to the smoke and dust of populous towns; there are, however, a few which are fairly satisfactory even under such conditions; namely, Holly, Ivy, Rhododendron, Privet, Aucuba, some of the Pines, Yucca, Cherry Laurel, and of course the Yew. [W. W.]

Everlasting Pea, a hardy and climbing garden perennial belonging to the nat. ord. Leguminosæ. See LATHYRUS SYLVESTRIS.

Eversion of the Rectum.—This accident occurs in horses and cattle, sheep and swine, while straining to pass hardened fæces, and in females during parturition or immediately after, when the expulsive efforts are made to rid the uterus of the placental membranes (see AFTERBIRTH), and occasionally during the pains of colic, without apparent preliminary straining. Young pigs, distended by swill and having large pendulous bellies, are specially prone to this accident in cold weather. The extrusion or eversion of gut may be slight, or in the larger animals prove alarming by the size and weight of the mass to be dealt with. *Treatment* must be prompt, or the effusion between the membrane and substance of the bowel

Photo. Chas. Reid

EXMOOR PONY STALLIONS (Acland Type)

Photo. Chas. Reid

FELL PONY STALLION—"MOUNTAIN HERO II"

is so great that return is not possible without the relief of small punctures to let out the purple-coloured fluid that accumulates. The extruded parts should be washed with a warm solution of carbolic acid and glycerine, or other disinfectant, and carefully reposed by the hands. The replacement does not prove so difficult as the retention afterwards. Stitches may be employed for this purpose, but a special clamp is now generally obtainable and is much preferable. Very little food should be given, and this of a concentrated kind that will not favour distension. A few grains of maize will suffice for little pigs for a few days until cured. [H. L.]

Eversion of the Uterus. See PARTURITION.

Evesham Moth. See CHEIMATOBIA BRUMATA.

Evil.—Much confusion arises from the survival of this old term, which had its origin in the belief in evil spirits or demons, as 'Puck', the god of mischief, who was supposed to strike with the evil (symptomatic anthrax). In Sussex the malady is still known as pook or puck. The evil may mean joint evil, or navel ill, or other diseases in various localities. See also POLL EVIL; JOINTS, DISEASES OF, &c. [H. L.]

Evolution.—The plants and animals now living upon the earth were preceded by a different flora and fauna, as the rock records plainly show. There was a time when there were no flowering plants, when there were no backboned animals higher than fishes. According to the evolutionist interpretation the forms of life we have around us to-day are the descendants of older types on the whole simpler; and there is no other scientific interpretation. We know how many breeds of domestic animals and varieties of cultivated plants have arisen within a few centuries or even years under man's eyes and under his control; according to the evolutionist interpretation the same kind of process has been going on for millions of years in nature, certain natural factors taking the place of the human breeder. The evolutionist maintains that the present is the child of the past and the parent of the future, and he seeks to give as circumstantial an account as possible of the steps in 'the great process of becoming'. In the strict sense the evolutionist interpretation cannot be proved, but there are no facts against it and there is cumulative presumptive evidence in its favour. Thus we know that there is great variability from generation to generation in natural conditions among wild animals just as there is among those which have been domesticated. In the latter case man has achieved much by selecting from among the variations that occur; it is reasonable to suppose that processes of elimination and selection which go on in nature may have achieved similar but much greater results in the course of ages. Affinities between one species and another are demonstrated by the comparative anatomist and embryologist; transition forms often link diverging genera together or connect them back to extinct types; interesting vestigial organs are quite enigmatical except in the light of the evolutionist interpretation; the stages in the development of an organ often seem to recapitulate the stages seen as permanent steps in a series of simpler types; these and many other considerations forcibly suggest that the evolutionist interpretation is in accordance with the facts.

While the general idea of evolution is usually recognized as a reasonable scientific interpretation of the mode in which the present-day fauna and flora have come to be as they are, there is considerable doubt in regard to the *factors* in the process. This uncertainty is due in part to the complexity of the problem, in part to the relative novelty of the enquiry—which practically dates from the publication of Darwin's Origin of Species in 1859, and in part to the fact that while there has been much theorizing, there has been till within the last ten years comparatively little experimenting or precise, connected observation as to the modes and causes of evolution. In a general way it may be said that the two great problems before the evolutionist are: (1) What are the conditions leading to the occurrence of those transmissible variations which form the raw material of progress (an enquiry into primary or originative factors)? and (2) what are the directive factors which may operate upon given variations, determining their elimination or their persistence, and helping towards the familiar but puzzling result—the existence of distinct and relatively well-adapted species? This is an enquiry into the secondary or directive factors of evolution, and at present it consists for the most part in attempts to define the scope of natural selection on the one hand and isolation on the other.

See Charles Darwin, Origin of Species (1859); Alfred Russel Wallace, Darwinism (1889); Bateson, Materials for the Study of Variation (1894); Weismann, The Evolution Theory (1905); Morgan, Experimental Zoology (1907). [J. A. T.]

Ewe Neck, a defect in horses and cattle characterized by the neck being hollowed above and not straight but bulging below.

Excambion, in Scots law, is the name given to the contract whereby adjoining proprietors effect an exchange of portions of their estate. Thus where a portion of each estate lies into the other, the proprietors can exchange the outlying portions so as to effect a straightening of the march, the difference in value of the lands exchanged being satisfied in money. [D. B.]

Exercise.—In order to maintain a perfect balance between secretion and excretion, exercise is necessary. The circumstances under which the various domesticated animals are kept, and the objects for which they are maintained, differ so widely that much latitude is permissible and even desirable. The working horse is at one end of the list and the fattening ox at the other; but exercise is desirable for both if all the functions of the body are to be efficiently performed and illness avoided. The heart, lungs, muscular system, and the joints all need the stimulus of exertion, or a tendency to congestion, failure of digestion, or lameness is liable to ensue. Horses

need more exercise than any other animal—unless we except the dog, and he is not subject to the filled legs and laminitis, or fever in the feet, which result from want of exercise in the horse. Condition or capacity for work can only be obtained by exercise, gradual and progressive in amount, trainers of racehorses and hunters having reduced the subject to a fine art. The greater the exertion, whether it is called exercise or labour, the greater the elimination of carbonic acid from the lungs, the more perfect the secretion of joint oil, the firmer the muscles, deeper the respiration, and more forcible the heart's contractions. The desirability of exercise for horses when not required to labour is generally admitted, but so often neglected that no apology is needed for enforcing it upon the reader, who will avoid many evils by compelling a modicum of exercise upon all horses; not excepting those who are stiff with severe work on the previous day, for to such a few minutes' walk may mean escape from serious leg troubles (see LYMPHANGITIS, WEED, &c.; also LAMINITIS). In the management of horned stock the need of exercise is too often forgotten, as they endure confinement with fewer bad results than horses; milch cows devoting their tissues to milk production, suffer less than fattening cattle; but all are benefited by moderate exercise, which enables them to digest and profit by more food, besides preventing overgrowth of the foot, so common among stalled cattle and bulls habitually kept in confinement. The want of exercise in young bulls may very well contribute to sterility, or to absence of sexual desire, of which many owners complain. Chronic fever in the foot joints of cows confined in stalls is due to want of exercise. Constipation in sows and boars, and cramp in young pigs, are often associated with want of freedom at exercise; and among the most successful pig-breeders we have known may be numbered those who stir up the litter of young during the long winter evenings, to make them empty the bladder, holding as these men do that cramp is due to retention of urine for many hours, when the warmth of the nest makes them reluctant to go out into the cold. All the animals of the farm are benefited by exercise, and in this may be included fowls, which will grow inert and loaded with abdominal fat and subject to apoplexy, if not compelled to scratch for some portion of their food and thus obtain beneficial exercise. [H. L.]

Exhaustion of Soils. See FERTILITY OF SOIL.

Exmoor Ponies.—The Exmoor ponies are undoubtedly the most typical ponies of all the native breeds, and they can be readily distinguished from any other by their smart appearance, fine bones, and generally well-bred look. The hills on which they range possibly afford better pasture and a greater variety of shelter than any of the other districts devoted to pony breeding, but for all that the Exmoor pony is very hardy, and can endure cold and wet as well as any of them. The breeders on Exmoor, like those on the Welsh hills, but different from those on Dartmoor and in the New Forest, have not favoured anything much over 11·2 hands or 12 hands high, and this no doubt accounts in a large measure for the hardiness of their constitution and their singularly typical appearance.

It is a curious fact that they succeed admirably as sires in the New Forest, Dartmoor ponies restoring to the filly foals at once the smart pony head which is so much prized by pony breeders; but this is by no means always the case with the colt foals so bred. One of the most successful sires known in the New Forest was an Exmoor bred by Sir Frederick Knight, and it is easy to pick out his stock of fillies in the Forest wherever he has been, while many of the colts are somewhat coarse. There is a brown colour with a mealy nose and flanks which may be said to predominate on Exmoor, and this also is very strongly prepotent when Exmoors are mated with other breeds.

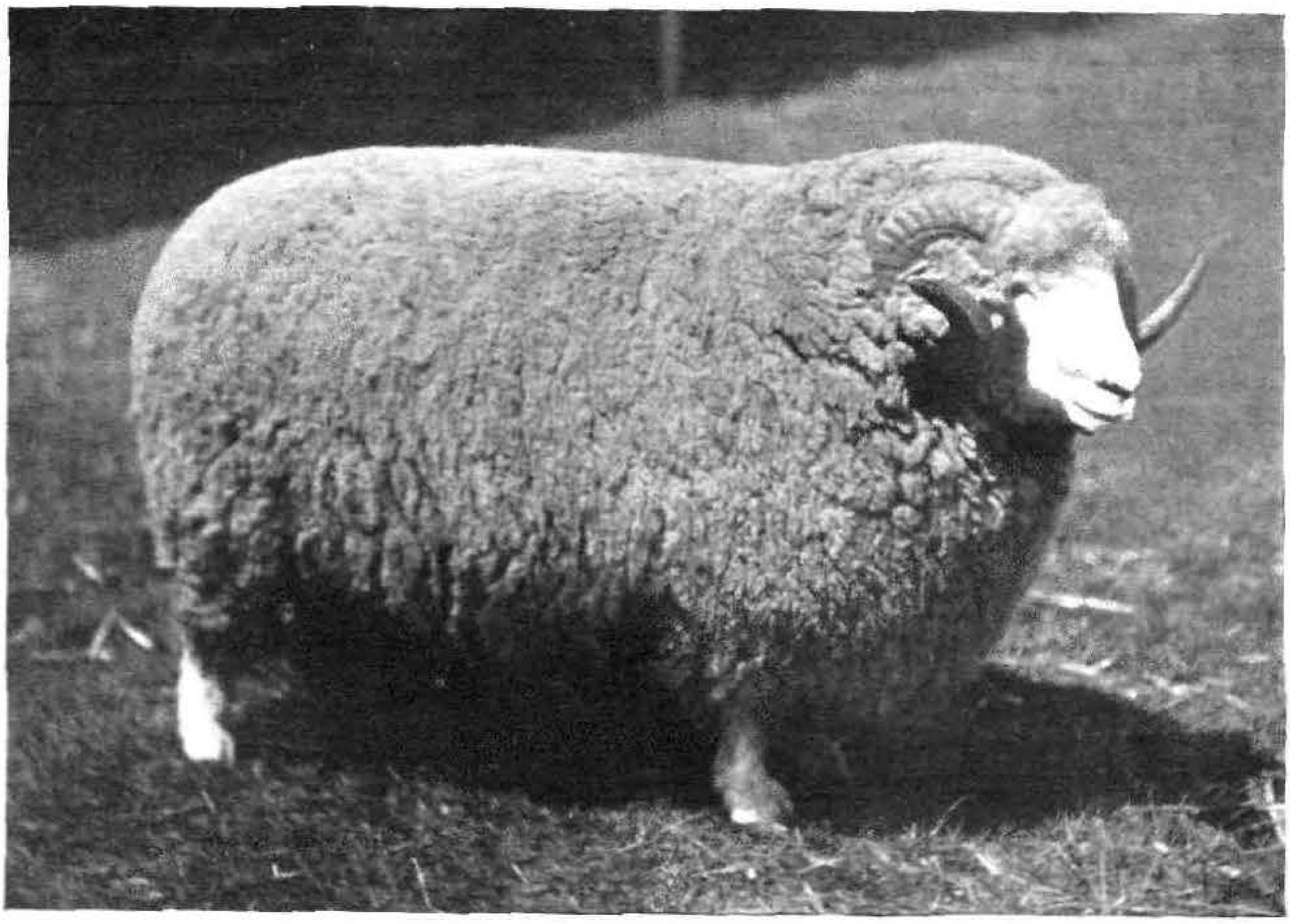
There are many legends of the origin of Exmoor ponies, notably the one of Katerfelto referred to by Whyte Melville; and whatever truth there may be in any of them, there can be no doubt that somewhere or other there has been a cross of Arab blood most judiciously introduced, and possibly also of thoroughbred blood.

For a fault, the Exmoor ponies are somewhat too light of bone for general utility, and they are, like the other breeds of south-country ponies, inclined to be a little short in the rump. It is a well-ascertained fact that many hunters and even some thoroughbreds are descended from Exmoor ponies, and wherever this is the case, immense staying powers are sure to be present. The Acland breed of Exmoor ponies is by far the most typical stamp of pony required for Exmoor, and the amount of courage and endurance shown by them is almost incredible. The best time and place to buy Exmoor ponies is at Bampton Fair in the beginning of October. [A. C.]

Exmoor Sheep.—The forest of Exmoor contributes a name to a pure breed of mountain sheep, which as a breed is indigenous to the hill districts of western Somerset and northern Devon. The horns of these animals are influenced as to size, as the animals are themselves, by the richness or otherwise of the land on which they are kept. Their heads are also remarkable for wool as well as for horns, being well protected against the blasts and storms of winter.

The Enclosure Acts have had much to do with modifying the Exmoors, in shape and size, on cultivated lands. Widely distributed throughout the hill region, and also in adjacent lowlands, there are now at least two well-differentiated types of this breed. In the first place there are the pure-bred flocks in districts that are too hilly for enclosure, or at all events for cultivation. It is on these wild, exposed lands that no liberties have been taken through crossing with alien blood, for fear of weakening the stamina, and thereby rendering the sheep less capable of resisting a severe winter climate.

But on the enclosed and cultivated farms, liberties with purity of breed have been taken somewhat extensively, with the object of increasing the size and improving the build of the



EXMOOR SHEARLING RAM
WINNER OF 1ST PRIZE, BATH AND WEST OF ENGLAND SHOW, 1908

EXMOOR HORN YEARLING EWES (SHORN)
1ST PRIZE WINNERS AT R.A.S.E. SHOW, 1907

sheep. This object has been attained by using Leicester blood, but at the cost of reducing stamina, hardihood, energy, and even numbers. These crossbreeds are locally known as 'Knotts', and are frequently hornless. Cheviots and Blackfaces have also been used for crossing, by way of experiment, but not with encouraging success. Some think it would have been better never to have crossed at all, but rather to have been content with blood replenishments from distant flocks of pure blood, and development from within the pale. Or, if crossing should have been resorted to, the results of such crossing should not have been employed in forming as it were a sub-breed whose pedigree was mixed.

Be this as it may, crossbreeding still continues, and a new breed of Exmoors, bigger and shapelier, but not hardier and sounder, has been developed. There can hardly be a doubt, however, for rich lands that have been highly cultivated, that a pure mountain breed, however susceptible it may have been to improvements, would not have been so well adapted as a new and bigger breed formed by grafting new shoots of a suitable stock. It is therefore probably correct to say that for the hills the breed should not be crossed, but kept pure for drafting ewes for crossing down below; whilst the lowlands should be employed to produce bigger sheep than those of the hills—sheep whose earlier maturity is a point not to be overlooked.

It is understood that pure-bred ewes are better nurses than those in whom alien blood predominates, that is to say, than the cross-bred ones, generally, though there may be exceptions here and there. This is what may be expected—a maternal function developed in deference to climatic requirements. Instances are not rare in which a ewe has suckled three lambs successfully. Such of these Exmoor flocks as run on the hills for the most part, are as a rule brought down to the lowlands as lambing time approaches, and are allowed turnips and oats in strict moderation. This allowance has a good effect, not only on the ewes themselves, but on the lambs as well. They are mated with the ram when they are coming two years old, and are usually kept in the flock for three breeding seasons, after which they are drafted out for sale. A few exceptionally good ewes, however, which are favourites, are kept on a year or two longer.

The Exmoors—especially those which retain all the characteristics of the breed in its purity—are essentially a grassland breed. In olden times they had no food but grass, or hay in winter. Since, however, sheep breeding has been a profitable calling, they have met with more generous treatment in times of need. Not that they are ever pampered, as some other breeds are, until their habits of life become essentially artificial. Grass, indeed, is the staple food for breeding flocks throughout the season, but it is found expedient to supplement it in winter and in lambing times. This, however, is sparingly done, except in regard to flocks which have been more or less altered by infusions of Leicester blood. And it follows, where early lamb is the object, that a more liberal course of feeding is found to be expedient, especially in rough weather. On many farms, however, these sheep, unmixed with other blood, get nothing at all but grass—no roots, or corn, or even hay. Those that are being fattened for mutton have a run on rape, which makes the best green crop for summer fattening, and which does not need supplementing by cake or corn. Ewes become associated with rams from September 20 to October 10 in the hill country; in the lowlands, from September 1 onwards. About 30 go to a yearling ram, and from 40 to 50 to older rams, and sometimes these latter numbers are almost doubled. About 130 to 140 per cent of lambs are expected.

No formal scale of points has as yet been drawn up by the Breeding Committee, but sheep with undesirable features and characteristics are not registered. Thick-set wool of medium length, capable of affording succour to its grower and wearer in the severest weather, is regarded as fundamentally necessary. The carcass should be well fleshed, with broad and even back and loins. It is also indispensable that the ewes should be good nurses, and this condition, fortunately, is seldom absent.

The more prominent breeders of Exmoors are to be found in the Flock Books as members of the Exmoor Horn Sheep Breeders' Society, vol. i. of which was issued in 1907. The Society was formed on July 28, 1906. By the end of the first year of the Society's operations, 120 members had joined, and about 11,000 'pure Exmoor Horn Sheep' had been branded with the 'Anchor' mark. Sir C. T. D. Acland, himself a breeder of these sheep, became the first president. [J. P. S.]

Exostosis, or **Bony Growth.**—Exostoses are a frequent source of lameness in horses, and no animal is exempt from the risk of such growths or deposits of bone upon bone when inflammation of the periosteum or covering membrane provokes the accumulation of calcareous or bony material. It should be remembered that bone seems to make most of its growth from the outside covering, which has been referred to above as periosteum, and any excitation of that membrane is likely to result in exaggerated or exalted function, with the result of more bone production than is required. Splints, ringbones, and spavins are common examples of exostosis. In their case the inflammatory action is set up by strain or excessive exertion, but blows from the outside, as upon the shins, often leave permanent enlargements which are true exostoses. When a broken bone unites, there is at first, and perhaps permanently, a superfluous deposit of bone which may be regarded as an exostosis. Sidebone is a conversion of cartilage to bone, and not true exostosis, although ofte. associated with it. Bone deposits being a frequent cause of lameness by reason of friction or injury to soft structures, call for treatment by firing, blistering, and the employment of so-called absorbents. See Blisters and Blistering, Firing, also Callus. In young animals the disposition to bone deposits is easily provoked, while in the old there is a tendency to absorption of all superfluous material. [H. L.]

Experiment Stations, Home and Foreign. — The interest in the application of science to agriculture, which was awakened in western Europe during the early part of the 19th century, led to the foundation of the earliest agricultural experiment stations. The first stations were private stations, which were instituted by individuals of sufficient means who were personally engaged in agricultural research. Thus the earliest stations definitely devoted to systematic research in agriculture were those of Boussingault at Bechelbronn in Alsace, and of Lawes at Rothamsted, England. No doubt earlier investigators had carried on field and other experiments, but they do not seem to have had the opportunity or means of obtaining stations for systematically carrying on their work. The Rothamsted station, which still continues one of the greatest centres of agricultural research in the world, was founded in 1843. Before this, Mr. (afterwards Sir John) Lawes, who succeeded to the estate of Rothamsted in 1834, had carried on field and laboratory experiments in agricultural chemistry, but it was in 1843 that he obtained the assistance of Dr. Gilbert, afterwards Sir J. Henry Gilbert, and began the systematic field experiments which were destined to become so famous.

Boussingault in France was similarly a man of position and a landowner, and carried on his agricultural station on his own property in Alsace. Most of the later stations were not, like these, founded by private persons, but were founded and carried on by agricultural societies, by provincial or national authorities, or by combinations of these.

For a long time the Rothamsted station continued the only station for agricultural research in Britain. The next stations were those founded by the great agricultural societies, such as the station at Woburn which has been carried on for many years by the Royal Agricultural Society of England with the help of the Duke of Bedford, and the station at Pumpherston which was carried on for a few years by the Highland and Agricultural Society of Scotland. With the exception of the station at Pumpherston, which unfortunately was not permanent, and a small station near Aberdeen carried on by a private association, the Aberdeenshire Agricultural Research Association, there were no experiment stations in Scotland till the West of Scotland Agricultural College acquired their station at Holmes Farm, Kilmarnock, in 1901.

Meantime, in other countries, agricultural experiment stations grew up very rapidly after 1850. The first German station was founded at Möckern, near Leipzig, in 1851. This station is in the kingdom of Saxony. The earliest Prussian station was founded at Halle, which is not far from Leipzig, in 1855. Other stations rapidly followed, such as Bonn in 1856, Göttingen, Marburg, and Dahme in 1857, and so on. At present there are stations of various kinds dotted all over the country, and their total number is very great. The latest official returns show thirty-eight stations of various kinds in Prussia alone, all in receipt of public money. This list, too, is not exhaustive, as there are a few other research stations which do not appear in it, such as those attached exclusively to the agricultural departments of universities.

In Germany the stations had their origin with agricultural societies and Chambers of Agriculture, and were taken up by the national and provincial governments, from which they now obtain a large part of their financial support.

The history of the stations in France is somewhat similar to that in Germany, and there are now a very large number of stations of many different kinds dotted all over the country. Many of these stations had a private, and nearly all of them had a local origin. They are, generally speaking, largely supported by the local governments of the departments in which they are situated, but in addition most of them receive support from national funds, and though not strictly State institutions are to a certain extent under the supervision of the central authorities, who see that the Director is properly chosen and is a properly qualified expert.

In the United States of America the first experiment station, that of Middletown, Connecticut, was established in 1875. Others were rapidly established, till now there is at least one in every State of the Union. The total number of stations given in the official list for 1907 is sixty. In no country are the agricultural stations more liberally supported than in the United States. The first stations founded were entirely supported by the individual States in which they were situated, but the Federal Government soon took the matter up, and under the Hatch Act large appropriations were made for the experiment stations from federal funds. These appropriations have been increased from time to time as the work has grown, and the public appreciation of it has increased. The latest increase was made in 1906, in which year a large appropriation was made to the stations from federal funds for the special support of original research.

In addition to the countries mentioned, experiment stations have been founded in nearly all other civilized countries, including some of the great dependencies of the Empire, such as Canada. The stations in most of these countries are, like those in Germany, France, and America, supported mainly or entirely from public funds. In regard to the number of stations, and to the support given to them, Great Britain is far behind most other countries. Though in the Rothamsted station we possess one of the oldest and most important of all agricultural experiment stations, we owe it to the scientific enthusiasm and public spirit of Sir John Lawes, and it does not receive any financial support from public money. The only stations in this country which are supported by public money are the recently founded stations or experimental farms attached to certain of the agricultural colleges and agricultural departments of universities. Even these are few in number, and the support given to the whole of them put together is not greater than that given to a single station in the United States. As yet there are no public experiment stations in this country, such as are found abroad, maintained

by public money entirely for agricultural experiment and research, without necessary connection with any teaching institution. Whereas agricultural experiment and research has developed abroad into a great and important department of State-supported work for the benefit of agriculture—which though more or less associated with agricultural education is independent of it—there is as yet no similar development in Britain.

Various different kinds of work are undertaken by experiment stations, and abroad, at any rate, there are a great many different kinds of institutions all engaged in agricultural experiment or research on different lines and in different subjects. In many cases several different kinds of work are carried on in the same station.

In Rothamsted we have a station devoted to the highest type of research work. It is engaged in trying to extend the bounds of knowledge. This is a kind of work which is of the highest importance of all, for it supplies the very foundations on which all advance must be built. At the same time this is the kind of work which is apt to be least understood and appreciated by the practical man, who can generally appreciate the practical applications of science, but not the pure knowledge without which there can be no practical applications. The work to which the Rothamsted station has mainly devoted itself is not the demonstration or application to practice of what is already known, its main work has been the higher but less appreciated one of searching for the fundamental principles on which all advance is based. The work is mainly of universal and not of merely local application. The work of Rothamsted typifies one of the kinds of work which is carried out by experiment stations. There are very few other stations in this country which are as yet equipped for higher agricultural research. Most of the college stations or farms are fitted rather for demonstration work, or for the working out of detail investigations suited to the particular localities in which they are situated. They carry on experiments intended to demonstrate the applications of knowledge to agriculture, and to work out local problems of more or less passing interest.

Both these kinds of work are carried on by foreign stations. Frequently in the same stations both higher research work and detail work, local work and demonstration work, are carried on side by side. The liberally supported American stations were at first largely engaged in what was really only demonstration and local work, and it was only gradually that some of them became engaged in higher research work. Not only have special men to be trained for research work, but before anything of value can be done, men with special aptitude for research have to be discovered. Higher research work

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and germination, and soils a
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to the station funds. In othe
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officers are analysed. In so
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and though the fees charged
siderable part of the revenue
is derived from this source.
enables these stations to keep
of analysts, botanists, &c., and
falls specially at certain times
times of year this staff can be
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arrangement is that such a
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At Rothamsted the investi
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ment station should not be a farm at all. A farm is a place where agricultural practice is carried out for profit, an experiment station is a place where experiments are carried out in order to increase knowledge or to illustrate or extend the applications of knowledge. In addition to the kinds of work already mentioned, certain foreign stations specialize in pot experiment work, others on research into dairying, others on research on the cultivation of moorland, and others still on bacteriology or soil physics. If we look at the official list of Prussian stations we find what a variety of agricultural work is included under agricultural experiment stations. There are stations for field experiments on plants, for pot experiments, for the investigation of plant diseases, for fruit culture, for moorland culture, for the investigation of questions concerning the sugar industry, for the investigation of animal nutrition and physiology, for the investigation of animal diseases, for the preparation of antitoxins and vaccination materials, and for the investigation of milk and dairying questions. In addition to these, there are the stations attached to the higher agricultural teaching institutions which carry on experiment and research for educational purposes. Something similar is to be found in all the other great civilized countries with the exception of Britain. [J. H.]

European and American Experiment Stations and Agricultural Colleges:—

Centres of chief Agricultural Colleges, Agricultural Departments of Universities, and Experiment Stations in France.

Arras.	Lyons.	Nantes.
Dijon.	Montpelier.	Paris.
Grignon (Seine-et-Oise).	Nancy.	Rouen.

Centres of chief Agricultural Colleges, Agricultural Departments of Universities, and Experiment Stations in Germany.

Berlin.	Hohenhein.	Marburg.
Bonn.	Jena.	Munich.
Breslau.	Kiel.	Rostock.
Darmstadt.	Königsberg.	Weihen-Stephan (Freising).
Göttingen.	Leipzig.	
Halle.		

Canadian Agricultural Colleges.

Macdonald Agricultural College, St. Anne de Bellevue, Quebec.
Manitoba Agricultural College, Winnipeg, Manitoba.
Nova Scotia Agricultural College, Truro, Nova Scotia.
Ontario Agricultural College, Guelph, Ontario.
Prince of Wales College (Agricultural Department), Prince Edward Island.

Canadian Experiment Stations.

British Columbia Experiment Station, Agassiz, B.C.
Dominion Experiment Station, Ottawa, Ontario.
Manitoba Experiment Station, Brandon, Manitoba.
Northern Alberta Experiment Station, Lacombe, Alberta.
Nova Scotia Experiment Station, Nappan, Nova Scotia.
Saskatchewan Experiment Station, Indian Head, Saskatchewan.
Southern Alberta Experiment Station, Lethbridge, Alberta.

The Agricultural Colleges and Experiment Stations, United States of America.

Alabama—
College Station, Auburn.
Canebrake Station, Uniontown.
Tuskegee Station, Tuskegee.
Alaska—Sitka.
Arizona—Tucson.
Arkansas—Fayetteville.
California—Berkeley.
Colorado—Fort Collins.
Connecticut—
State Station, New Haven.
Storrs Station, Storrs.
Delaware—Newark.
Florida—Gainesville.
Georgia—Experiment.
Hawaii—
Federal Station, Honolulu.
Sugar Planters' Station, Honolulu.
Idaho—Moscow.
Illinois—Urbana.
Indiana—Lafayette.
Iowa—Ames.
Kansas—Manhattan.
Kentucky—Lexington.
Louisiana—
State Station, Baton Rouge.
Sugar Station, Audubon Park, New Orleans.
North La. Station, Calhoun.
Maine—Orono.
Maryland—College Park.
Massachusetts—Amherst.
Michigan—East Lansing.
Minnesota — St. Anthony Park, St. Paul.
Mississippi — Agricultural College.
Jackson.
Missouri—
College Station, Columbia.
Fruit Station, Mountain Grove.
Montana—Bozeman.
Nebraska—Lincoln.
Nevada—Reno.
New Hampshire—Durham.
New Jersey— New Brunswick.
New Mexico—Agricultural College.
New York—
State Station, Geneva.
Cornell Station, Ithaca.
Santa Fe.
North Carolina—
College Station, West Raleigh.
State Station, Raleigh.
North Dakota — Agricultural College, Fargo.
Ohio—Wooster.
Oklahoma—Stillwater.
Oregon—Corvallis.
Pennsylvania—
State College, Center County.
State College, Institute of Animal Nutrition.
Porto Rico—Mayaguez.
Rhode Island—Kingston.
South Carolina — Clemson College.
South Dakota—Brookings.
Tennessee—Knoxville.
Texas — College Station, Bryan.
Utah—Logan.
Vermont—Burlington.
Virginia—Blacksburg.
Washington—Pullman.
W. Virginia—Morgantown.
Wisconsin—Madison.
Wyoming—Laramie.

Exports, Agricultural.—For a country which has to rely so largely on imports of agricultural commodities, the dimensions of the export trade in native produce is not to be overlooked. Taking account only of the particular items of agricultural produce shown as exported in the annual statistics of the Board of Agriculture in the course of the year 1907, it seems that against our large imports of grain we sent away again nearly £2,000,000 of foreign cereals, besides exporting over £2,600,000 worth of grain, its offal and its products credited in the official accounts as produce of the United Kingdom. In these lists appears another £300,000 credited to rice (which, of course, was not grown, but only cleaned or milled in the United Kingdom). Besides these totals there was a formidable item of 'Biscuits and Cakes'—at all events manufactured here—shipped to foreign customers, and valued at £1,000,000 beyond the figures quoted. British hops and potatoes and seeds are likewise all represented in the export tables. Another form of export, which is at all events placed on board the vessels leaving our shores, may be found in the consignments of beef, pork, bacon, hams, mutton, poultry and game, which, so far as they are distinguished in the Customs records as British produce, represent a value exceed-

ing £900,000 a year. Even more than this, or £862,000, was credited in 1907 to exported British dairy produce, whereof £714,000 worth was condensed milk.

Even this list does not exhaust the exports of animal origin, for the grease, tallow, and animal fat exported in 1906 exceeded in value a million sterling. The raw hides exported are put at £520,000, and the skins of sheep and lamb are valued at over £700,000. Even rabbits' skins and those of other animals and furs exceeded a million pounds in value. It may be questioned if these items are correctly entered as British produce, but it is noteworthy that the single item of British-grown wool alone was valued for export at £1,790,000.

It will be observed that none of the items thus far enumerated include, what is most usually in the mind in speaking of British agricultural exports, the annual exports of live animals. These, for the year 1906 aggregated a value of close upon £1,800,000—a figure, however, which must be dissected rather carefully into its component items, as the year in question was an exceptional one in furnishing under the head of 'Horses' alone exactly two-thirds of the twelvemonth's value of animal exports, or £1,200,000. In 1907 the aggregate of the animal exports was a good deal less, or £1,544,000, whereof horses were £1,129,000. The last two years' horse exports were much beyond the annual average of the horses exported in several preceding years. Large values are always recorded for certain thoroughbred horses, but at the other end of the scale may be noted that out of over 60,000 horses exported, nearly 30,000 were only worth £10 per head, and 20,000 more £13 each.. Leaving horses out of account, however, there was sent abroad from British farms in 1906 a total of 5616 cattle valued at £327,000; 12,716 sheep, valued at £204,000, and 2221 pigs of a total value of over £20,000. The cattle exports of the year 1907 have not fallen very far short of those of 1906, or 5066 head, the sheep being 10,000, and the pigs 1360, the values credited to each class being in round numbers £227,000, £135,000, and £11,000 respectively in the later year.

As an indication of the special grade of the exports of live stock, it may be noted that the cattle of 1906 averaged £58 each, the sheep rather over £16 each, which are higher figures than have been shown for twenty years before. The averages for 1907 make the figures respectively £45, £13, and £8. It may be interesting to note the countries which take the main part in this very special export trade. Of the cattle shipped in 1906, some 2329 head, at an average value of over £92 each, went to Argentina alone —a country which also took 8000 of the sheep, or two-thirds of the whole exports, and paid very nearly £20 a head for them. Including the horses purchased by the same country at £214 per head, Argentina was estimated to have purchased half a million's worth of British live stock in 1906. In 1907 the Argentine purchase totalled less than half this aggregate, only the pigs being more numerous. Nearly half of the swine exported in 1906, or 1063 out of 2221, representing a value of £10,000 out of £20,000, seem to have been purchased for improving the breeds of the Austro-Hungarian empire, whereas in 1907 it was Argentina which took 752 pigs, or more than half the export, and no Austro-Hungarian trade is recorded. The South American republic of Uruguay was the second largest purchaser of cattle in both 1906 and 1907. It appears that Canada took 1135 British sheep in 1906, and 2710 in 1907, at a value of £7253 in the former and £16,191 in the latter years.

[P. G. C.]

Exposure.—The chief factors included under this term are the situation of a locality as regards altitude; its proximity to the sea; its slope, whether towards the midday sun or from it; the direction of the prevailing winds; and the proximity to forests. These are all important factors determining the climate of a country or district. Their general bearing upon agriculture may, however, be considered here. The fundamental factor in climate is the amount of heat which a place receives, and this is directly affected by all the factors named. The amount and character of the vegetation, and consequently of the animal life dependent on it, is ultimately governed by the total heat received during its growing period. In exposed situations, whether owing to high altitude, easterly or north-easterly winds, slope away from the midday sun, &c., the mean temperature tends to be low, and sufficient heat may not be available within the limits of a season for particular crops. A further circumstance is that in such situations crops not only require a longer time to ripen, but they may actually in the long run require more heat. While this is so, Boussingault's general conclusion appears to be approximately correct, viz. that 'upon every parallel of latitude and at all elevations above the level of the sea, the same plant receives in the course of its existence an equal quantity of heat'.

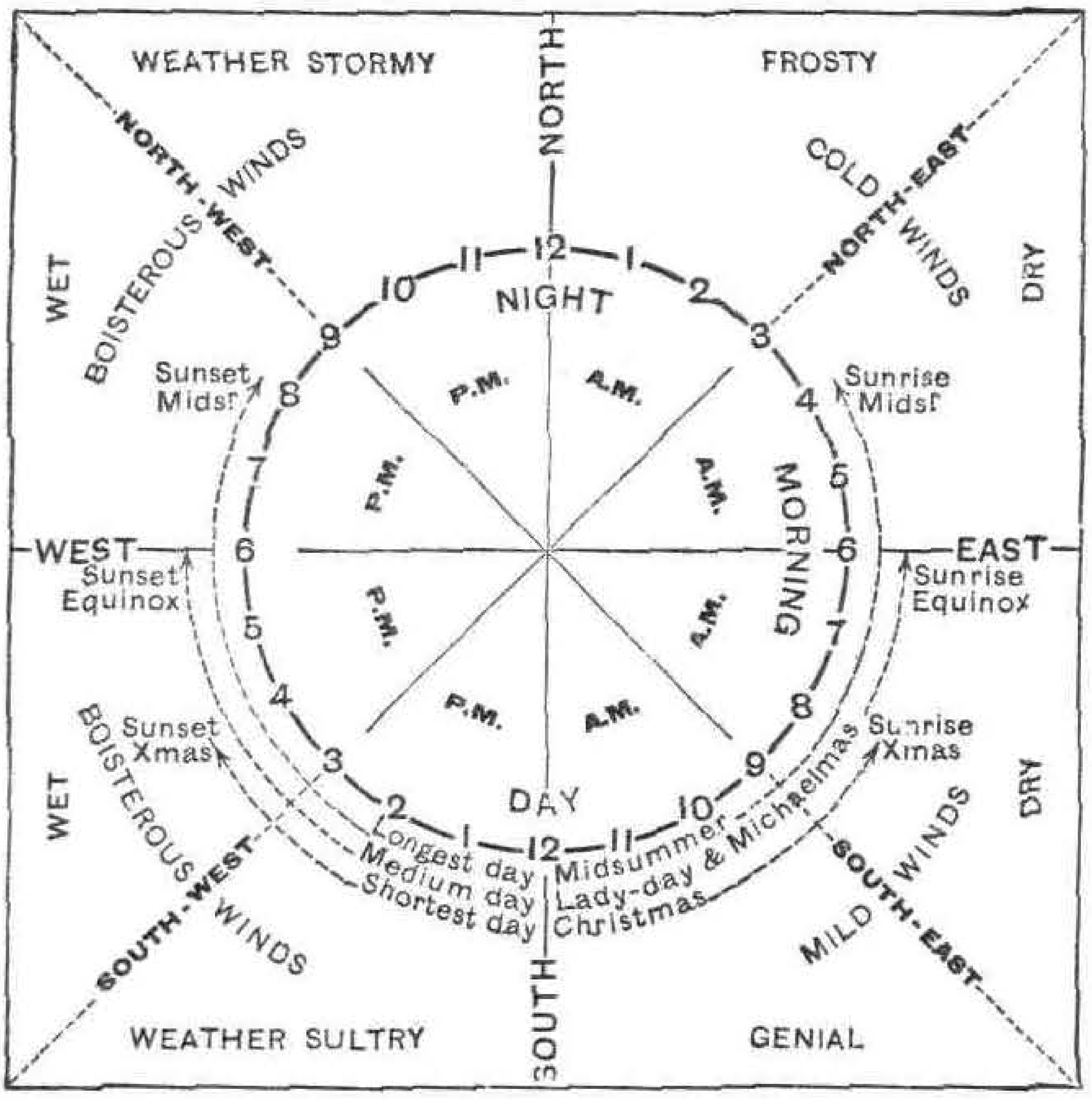
The range of temperature for the undermentioned crops has been given (Stephen's Book of the Farm) as follows:—

Wheat	78°–44° F.
Barley...	80°–59° „
Potatoes	78°–52° „
Flax	74°–54° „

Wheat is stated to require an average summer temperature of not less than 58° F. This means that here it cannot be successfully cultivated at an altitude over 600 ft. It refuses to ripen at much higher altitudes, *e.g.* 1000 to 1200 ft. In Scotland 57° is sufficient, because the summer days are longer, with the result that the total solar heat received, other factors being the same, is as great as that in the south. Corn does not grow below 40°, nor ripen below 48° F., and 56° F. has been given as the mean temperature between March and October below which no crops will ripen.

But all the different factors in exposure will have an influence on the crop. Much will depend upon the prevailing winds, slope, as well as other conditions. For example, west and south-

west winds coming from the Atlantic ocean are saturated with moisture and warmed by the Gulf Stream, causing a mild and wet climate on our western coasts, while the east and north-east winds are colder and drier, producing the more rigorous climate of the eastern coast. In high, exposed situations the rainfall may be twice or three times that of localities on a lower level. When strong winds are intercepted by striking such elevated lands, the moving air is forced to ascend into higher colder regions, its vapour is condensed and falls as rain. Forests also increase the rainfall of a district. Their effect upon the daily temperature is to make the days cooler and the nights warmer, to lower the summer temperature and to raise that of the winter; consequently in high and otherwise exposed situations which are well wooded, the winter climate is distinctly and favourably modified. [J. R.]



'Aspect' Compass

The diagram shows the normal characteristics of the winds blowing from the different points of the compass, and of the weather which may be expected while they prevail. Thus, south-west winds are generally boisterous in this country, bringing rain and heat.

On the dial in the centre is shown the length of the day (from sunrise to sunset) at Midsummer, at the Equinoxes, and at Christmas.

A southern 'exposure' is always preferable to a northern one, and there can be no doubt that the fall or slope of the land affects it materially in its relations to light and temperature. A southern aspect may also protect it from cold winds, or constitute in itself a certain degree of shelter. That ricks are often stripped of their thatch, newly clipped sheep seriously injured, corn crops levelled, or the grain blown out from the straw on the eve of harvest, are all instances of the dangers of exposure. The contrary effects of shelter need not be insisted upon, but the evil effects of exposure in unprotected situations is sufficient to affect the productive power of soils, and the wellbeing of live stock. We all know the attractions of 'sheltered vales'; and exposed heights are the best foil by which the value of such situations is made evident. In countless cases both of these conditions are found to exist on the same holding, and the differences are such that a month's interval in respect of seeding and harvesting may easily be the consequence.

The quality of barley is affected by slope and exposure. A field possessing a southern, south-eastern, or south-western slope will produce a better sample *cœteris paribus* than a field which inclines to northern segments of the horizon. The matter is not confined to single farms, but extends to valleys and districts. It may here be remarked that in the Chalk counties of southern England the soils on the northern slopes of the Downs are superior in fertility to those upon the southern slopes, but this is due to geological differences, produced by denudation at a remote period of time. It does not affect the general conclusion that the climate of the northern slopes of valleys is warmer and longer illuminated by the sun's rays than the southern slopes of the same valleys. The length of the shadows is a proof that the solar light is less concentrated wherever the shadows are longer, as is the case on a steep southern slope. A moment's reflection will show that the northern slope faces the south, and the southern slope faces the north. To say that a farm or a field 'lies well' is simply a popular mode of expressing the same fact, and it is brought out particularly in the case of vineyards, or in the cultivation of the more delicate kinds of produce. A rampart of hills in many cases confers protection on thousands of acres, and even belts of trees may save land and live stock from the evils of exposure. The subject is a large one and includes others of a kindred character, such as aspect, climate, and shelter, each of which will be considered separately. The degree of exposure influences the descriptions of crops, and the varieties of cereals, &c., selected. It is not possible in this connection to enlarge on this part of the subject; but in exposed situations, whether near the coast or inland, the selection of cereal crops should exclude any varieties incapable of resisting gales of wind, sea-frets, and cold nights. Similarly the class of live stock kept should be able to

stand exposure. Jersey cows or even Shorthorn cattle are not well fitted to stand the rigours of an exposed situation to the same extent as, for example, West Highland cattle.

In farm buildings, protection should always be provided against north and east winds, and they should be so planned as to give the yards a southern aspect. It is the same with lambing pens, which should be well backed up against the north and east, and open as far as possible to the south. In a word, the degree of exposure is an important matter as regards the land, buildings, and homestead. Exposure is to some degree controllable, but in general it belongs to the situation, and may amount to a serious drawback.

Exposure tends to develop strength of constitution in races of both animals and plants, and it is no small advantage to the grazier to purchase stock from cold and exposed situations. Such cattle generally do well when brought on to less exposed land, and the same is true of seed corn which has become acclimatized to the rigours of an exposed situation. [J. Wr.]

Eye, Diseases of.—There are fewer inherited diseases of the eye in animals than in man, but possibly more accidental injuries, lesions resulting from specific diseases, as periodic ophthalmia in the horse and distemper in the dog, which lead to blindness (see BLINDNESS, also CATARACT). Accidents in harness or by contact with nails and other things in stables account for many injuries to the organ, and still more to its appendages. Torn eyelids, the presence of hay seeds, of flies, and other foreign bodies are common troubles among horses, working oxen, and dogs. Before attempting to repair a damaged eye, the attendant should avail himself of a strong solution of cocaine with which to render it insensitive in a few minutes, after which he may employ fine sutures to bring the torn lid together, or use a camel-hair pencil to remove a foreign body. The resistance (from fear) of horses is most difficult to overcome unless so provided. No fraction of a lacerated eyelid should be cut off, but every endeavour made to save the smallest 'rag', as experience teaches us that nature exerts special care to bring together lacerated lids, and effects the most beautiful repairs where the novice would deem the case hopeless. In all injuries or diseases of the eye a cool dark box or one free from sunshine should be chosen, and where no flies are found. Simple antiseptic cooling lotions should be employed, and it is usually advisable to give an aperient. Common inflammation of the covering membrane (*conjunctiva*) from a stroke of the whip lash, from flies or other outside causes, results in overflow of tears, redness, followed by opacity of the front of the eye, including more or less of the cornea, and temporary blindness. If the injury is not severe this opacity will gradually clear up, beginning on the outer circle and leaving only a slight nebula, which seldom interferes with sight. A more severe injury may result in ulceration of the cornea and escape of the aqueous humour. If the iris and lens remain uninjured, repair of the front of the eye may take place, the chamber refilling and the convexity of the globe being restored; but there will remain a scar or white cloud constituting unsoundness, although not necessarily interfering with vision. Ulcers of the kind are a common sequel to distemper in dogs, and here again the reparative process is quite remarkable if the animal is soon restored to bodily health; but when of long duration owing to continued debility, structural changes within leave the sight very much impaired, or the dog is wholly blind. Besides the ophthalmia induced by external violence or foreign bodies, there is a constitutional and recurrent form in which the deeper structures are involved, and with each attack further serious lesions may be expected. The horse, ox, and dog are subject to these periodical visitations, and sheep are specially liable to an eye blight or infectious conjunctivitis, which is of temporary inconvenience only as a rule, and soon yields to simple antiseptic treatment.

Amaurosis, gutta serena, or glass eye is a condition in which the organ remains perfectly transparent, but the animal is blind owing to paralysis of the optic nerve. This is caused by blows on the head, or by cumulative poisons, as so-called Indian peas (*Lathyrus sativus*), and in young bulls confined in boxes is associated with an astigmatic condition. A bulging or too prominent eye distended by excess of aqueous humour shortens the focus and causes 'short sight', and shying as it is called. An opposite condition in old horses, whereby the range of vision or focus is affected, may also cause shying; but it is the experience of horsemen and veterinary surgeons that extensive cataracts of the lens or its covering may exist without the troublesome habit of shying (see CATARACT).

Staphyloma or grape upon the eye commences as a bulging from the aqueous chamber, and later takes a solid form. Cattle and dogs are most subject to this serious disease, which needs an operation for its removal, or the employment of powerful caustics under professional direction. [H. L.]

Eyebright (*Euphrasia officinalis*) is a small-sized and shortlived representative of the Foxglove order, viz. Scrophulariaceæ, which frequently occurs as a weed not only in poor heath pastures, but in pastures on the finest clays. It is distinguished from other members of its order by the four-toothed calyx, and the white two-lipped corolla spotted with yellow and veined with purple. The roots work in two ways—(1) as ordinary roots, (2) as parasitic roots which enter into the roots of the neighbouring grass plants and extract nutriment therefrom. Although this plant has a touch of parasitism, it seems to do very little damage to the grasses whose roots it attacks. The stem may be as low as 2 in. on poor heaths and as high as 8 in. on rich clays. The leaves are small and deep-green, opposite, and lobed. The uppermost have flowers in their axils, and so the terminal leafy spike is formed. The fruit is a dry, two-chambered seed case containing numerous minute seeds. The plant is an annual. Herbalists recommend a decoction of it as a remedial agent for weak eyes. [A. N. M'A.]

Eyed Hawk Moth. See SMERINTHUS.

F

Faba, the genus of plants to which the Bean belongs. See BEAN.

Fabiana, a genus of Solanaceæ with habit and foliage so much resembling some of the Ericas that the species grown in gardens, viz. *F. imbricata*, is known as the False Heath. It forms a shrub about 3 ft. high, clothed with small evergreen leaves, and in June the shoots are wreathed in white trumpet-shaped flowers. A native of Chile, it is hardy only in the warmer parts of the British Isles; in South Cornwall, for instance, it is a popular garden shrub. [W. W.]

Factor.—In Scotland the land or estate agent is termed factor. The house agent is similarly house factor in the north. The duties and training of the factor have already been specified under the head of AGENT, LAND. In Scotland the factor is in some instances raised to the dignity of commissioner, which implies that he is authorized to sign leases, feu contracts, and such like on behalf of the owner of the property. On one or two ducal estates the factor ranks as chamberlain. The Scottish law agent frequently acts as factor, more especially on the smaller estates. Generally speaking, the estate-farms that are freest from his control are for obvious reasons the most appreciated by advanced farmers. [R. H.]

Factories, Dairy.—Associated cheesemaking was first established in Switzerland, where it is flourishing still. At least a century it dates back, in its application to summer pasturing of cows on Alpine ranges, and to winter dairying in the lowlands and valleys, where milk is produced. In some cases the milk is carried long distances daily in large wooden vessels slung on men's shoulders. Emmenthaler cheese is generally made in these co-operative dairies. In 1851 it was tried experimentally, near Rome, in the State of New York, U.S.A., by Jesse Williams, who, uniting his son's dairying with his own, made into cheese in his own dairy the milk produced on both farms. From this small foundation has arisen the immense system of co-operative or associated dairying which prevails to-day in the United States of America and in Canada.

The first cheese factory in England was a converted mill in the town of Derby, and the first one built in this country was a wooden structure, on the American model, and was erected on the estate of the Hon. E. K. W. Coke, at Longford, a few miles from the county town of Derby. The superiority of country over town was demonstrated in these two cases. This was in the year 1871. The method of cheesemaking employed in these two pioneer establishments was the American factory method, and this in its turn was an adaptation of the English Cheddar method, which had been introduced into the United States.

These two establishments were managed by the brothers Schermerhorn, who were brought over for that purpose. The cheese they made was a high-class type of the American cheese which had become familiar to everybody in England; but it was American for all that, and not at all English, though it was made on what was known as the 'American Cheddar' method. And all the difference between the English and the American Cheddar lay in the manner of introducing and developing the lactic acid, which is fundamentally indispensable in both. In the old Cheddar method the acid was introduced by sour whey at renneting time, and was therefore at work during coagulation. The American modification consists in developing acid by cooking the curd, after coagulation. The modern, greatly improved, and scientific method is practically identical with the early Cheddar way, except—and in this lies the important difference—in the use of 'pure cultures' of lactic acid bacteria to develop the lactic acid, instead of using the acid whey from the previous day's work. In this way has it become not only feasible but easy to employ the true Cheddar method even in factories on a big scale.

Cheese factories have not multiplied in number in England, as they were expected to do at first. The introduction of cheese factories into England was, in point of fact, contemporaneous with the early stages in the development of the country milk trade, which has rapidly increased from year to year.

Creameries for the making of butter on a scale corresponding with that of cheese in factories did not until some years afterwards recommend themselves to English farmers, and then only in a few isolated instances. In Ireland, however, the result has been different, though even there, in the country best adapted for buttermaking, they were late in being established. They are now, however, numerous, and have resulted in the production of uniformly excellent butter. It is widely enough known and affirmed that the creameries of Ireland have already improved the average quality and character of Irish butter. This improvement, coincidently with numerical increase in creameries, is naturally progressive. The fact, indeed, has been established abundantly that in large creameries the finest class of butter can be made with precision and uniformity, to a degree far higher than the average farm dairies can lay claim to.

Among leading merits of co-operative or associated projects for making cheese or butter may be cited these:—

1. Centralization of work, of superintendence, of responsibility.

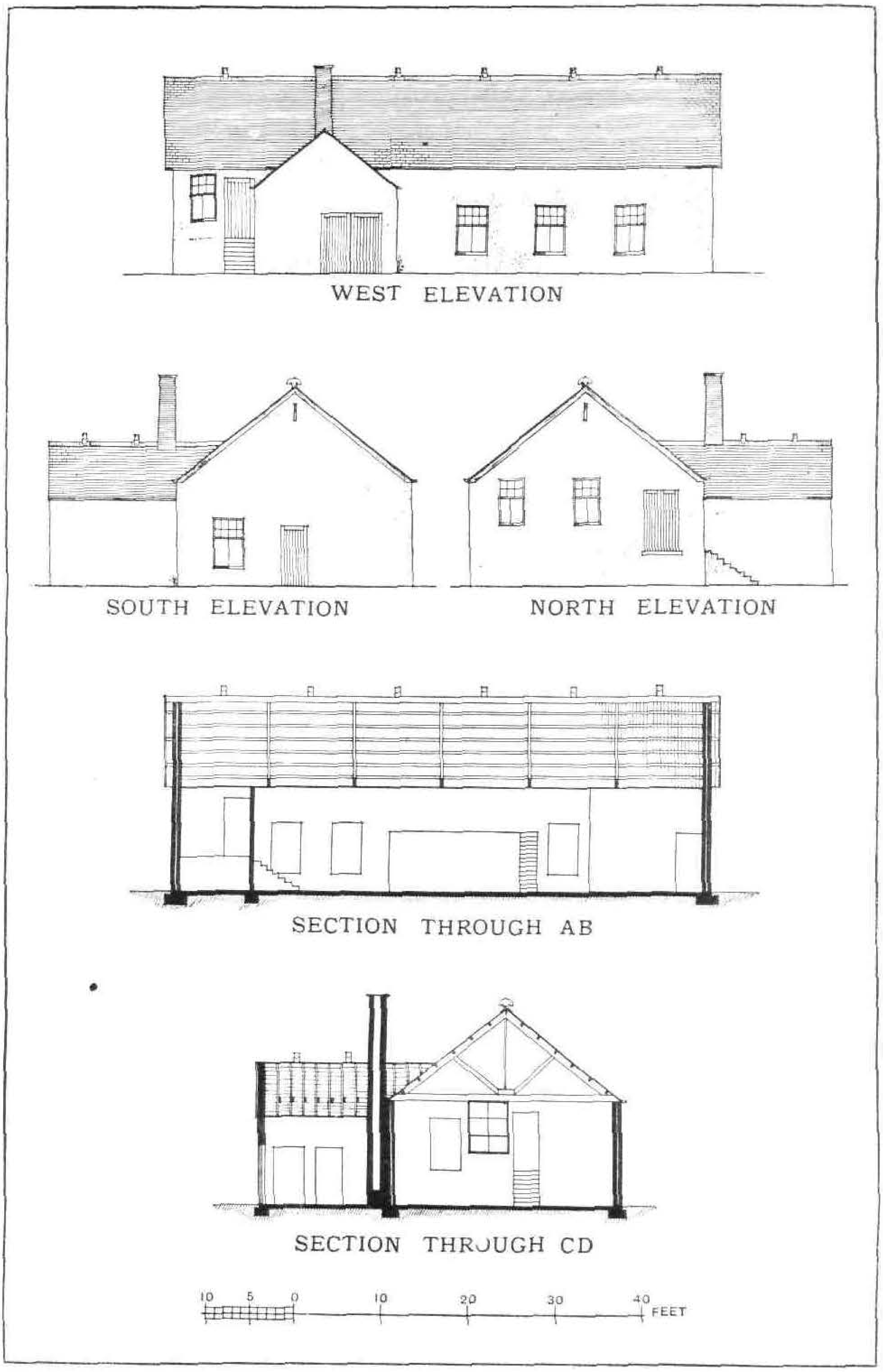
2. Large amount of milk brought under the control of a skilled expert in cheesemaking or in buttermaking.

3. Economy in labour, three persons in a creamery accomplishing the work of thirty in small farm dairies.

4. Cheapening of supplies, and lessening of 'wear and tear'.

5. Greatly improved facilities and advantages in selling products.

DAIRY FACTORIES—I



ELEVATIONS AND SECTIONS OF BUTTERMAKING FACTORY

6. Greater uniformity of type, quality, and character in the products, than can possibly be realized in any number of farm dairies.

7. Development of the co-operative spirit.

The cost of setting up a cheese factory or a creamery will depend much on circumstances and on management. If a building has to be erected to accommodate the milk of 500 cows, plus the necessary fitting up and equipment, the outlay may run up to or exceed £2 per cow. All will depend on the way things are done, and on the men who do them. Farmers uniting to fit up a factory will be well advised to inspect certain existing establishments similar to that which they think they want for themselves. [J. P. S.]

Factories, Dairy, Construction of.—A reference to A, Plate II, with relative elevations and sections (Plate I), will make plain the arrangement of a factory devoted to buttermaking. It is typical of the creameries one meets with in Ireland. The carts bringing milk cans draw up alongside the milk-receiving floor. This floor is 4 ft. or so above the floor of the general room or hall, and of the ground level outside. The difference in level is for the purpose of allowing the milk to gravitate directly to the pasteurizer and separator. Otherwise it would require to be pumped there. Unless it can be so arranged that this end of the building is on higher ground than the remainder, an inclined plane of earthwork requires to be constructed, to enable the carts to be brought into such a relation with this floor that the cans when in the vehicle are level with the floor, and can be drawn thereon without the necessity of their being lifted. It is advisable in nearly all cases, however, not to build against high ground, because the part of the building so situated can hardly be otherwise than damp; and dampness in a building is against good work of nearly every kind. There is not much difference of level implied in this case, consequently it is not a very formidable affair making it easy for the carts to get up to the level of the floor referred to. A suitable gangway of timber can easily be constructed.

On this floor the milk is weighed and sampled, and thereafter poured into a large receiving vat. The samples are bottled and laid aside until testing time. The manager's office, in which this is done, adjoins the milk-receiving floor. From it he can command the whole establishment. Part of the partition between the office and the place first referred to is of glass, while the same holds good of the side of the office next to the central hall. And a doorway puts him in communication with the delivery floor for by-products. A stair leads him directly down into the hall, while another in the adjoining receiving room affords him an exit from the building. The power house is at the side of the building, and consists of engine room, coal house, and boiler house. A strong engine is usually required, seeing that a considerable amount of power is necessary to keep the machinery going. There are several pumps to work; there is the separator and the churn to drive; and the freezing machine requires a considerable force spent upon it. And a good deal of steam is needed for the pasteurizer, for the heating of water, the scalding of pipes, utensils, dishes.

Whenever there is as much milk in the receiving tank as will charge the pasteurizer, it is turned on to the latter. From there it is delivered into the separator, the cream therefrom being led into one cistern and the skimmed milk into another. Each of these has now to be raised to a higher level—the cream to the ripening tanks or vats, and the skim milk to where it can be delivered into the cans of the men who have just brought milk with them. The cream vats are placed high enough to admit of the cream gravitating directly into the churn. And in the room set apart for the delivery of by-products the cistern for the skimmed milk is placed high enough to admit of the farmers' cans or churn-shaped tins being filled as required without their removal from the cart. In both cases the milk is at a comparatively high temperature, not having had time to cool down since its emergence from the pasteurizer, and has consequently to be cooled more or less—the cream down to the temperature at which it will ripen to most advantage, and the skimmed milk to one that admits of its being dealt with in an ordinary way. The cream is cooled by means of various devices, while the skimmed milk is simply run over a corrugated refrigerator as it passes from the cistern to the milk cans.

On the plan we are dealing with we have indicated the position on the floor of the various mechanical agencies. The pasteurizer and the separator are close to the milk-receiving floor; while the pumps for the disposal of both the cream and the milk are as near to these as practicable. Farther down the floor the churn is fitted up. This is a big barrel-shaped affair capable in most cases of turning out half a ton of butter at one operation. It is desirable that somewhere near to this the cream-ripening vats should be placed. We show a stage for the reception of these vats at the side of the building in a line with the position of the churn. The stage is high enough above floor level to allow the cream to be passed from the vats to the churn by gravitation. Some may wonder at the cream being allowed to ripen exposed to the air of the general-purpose room or hall instead of being in a quiet, well-regulated place of its own. This would mean extra building, however, with in all probability removal to a farther distance from the churn. In the hall there is no dust, the floor being more or less wet and the air moist. Besides, it is only there for twenty-four hours, the cream of one day being churned the next. Near the churn comes the butter-washing trough, and after it the butter-worker. All that now remain to complete the place are the shelving shown at the one corner, and the store—cold or ordinary—at the other.

A simple-looking affair is the whole concern so far as the plan reveals. In reality, however, there is a good deal of shafting, belting, and piping throughout the place. On the plan the hall or main part of the building looks large

enough, but when all comes to be in working order it will be found that there is little room to spare.

The plan shows the outer walls of the main building, constructed of two thicknesses of single brickwork, with a 3-in. space between—in all 12 in. The other walls are of 9-in. and 4½-in. brickwork. The outer surfaces can be rough-casted or pointed; inside, the surface may either be pointed and whitewashed or plastered—where money is plentiful it may be of enamelled bricks. The walls may of course be of stone as well as brick; or they may be of wood and iron. This, however, is very much a matter of circumstances. The light may either be admitted through side windows, as the plan shows, or by windows in the roof. The roof is supposed to be slated, but it may be finished with corrugated iron with skylights fixed therein. With the exception of the office the various places are intended to be without ceilings. And with the same exception the floors should be of Portland-cement concrete as being an impervious substance, easily cleansed, and sufficiently durable.

The Irish creamery, being concerned with butter alone, is of simpler construction than those factories that take up cheesemaking as well. More room is wanted in the latter case. The vats take up a good deal of space, and so do the cheese presses. By making the hall a little wider than that of Plan 1, say 5 ft. more, this extra space may be found. Only one operation will go on at a time, so that when buttermaking is at a standstill there will still be more room available. Were it practicable to shift the buttermaking plant at these times, almost the whole of the hall floor would be at the cheesemaker's disposal. This is never likely to be the case, however. Still, the latter would have more room when the buttermaking plant was idle than when in full force. But over and above that space of the hall he could utilize for his manufacturing purposes, the cheesemaker would of necessity require a separate place in which to lay past the cheeses while they were ripening. To provide this we show on Plan B, (Plate II), which otherwise is almost identical with Plan A, an extra building at the side of the hall opposite to the engine house. This would be fitted with shelves arranged somewhat as the plan indicates.

So long, therefore, as it could be arranged for the milk suppliers to take the whey, as at present at the Irish creameries they take the skimmed milk and the buttermilk, little beyond the extra 5 ft. in breadth of the hall and the additional room in which to ripen the cheese is needed to make a creamery such as on Plan 1, fitted to carry on cheesemaking as well. Indeed, the place might be kept at the original width of 25 ft., as it remains on Plan 2. By keeping the cream-ripening stage farther down the hall than on Plan 1, we get increased room at the head of it, where the curd vats would be likely to stand when cheesemaking was being conducted.

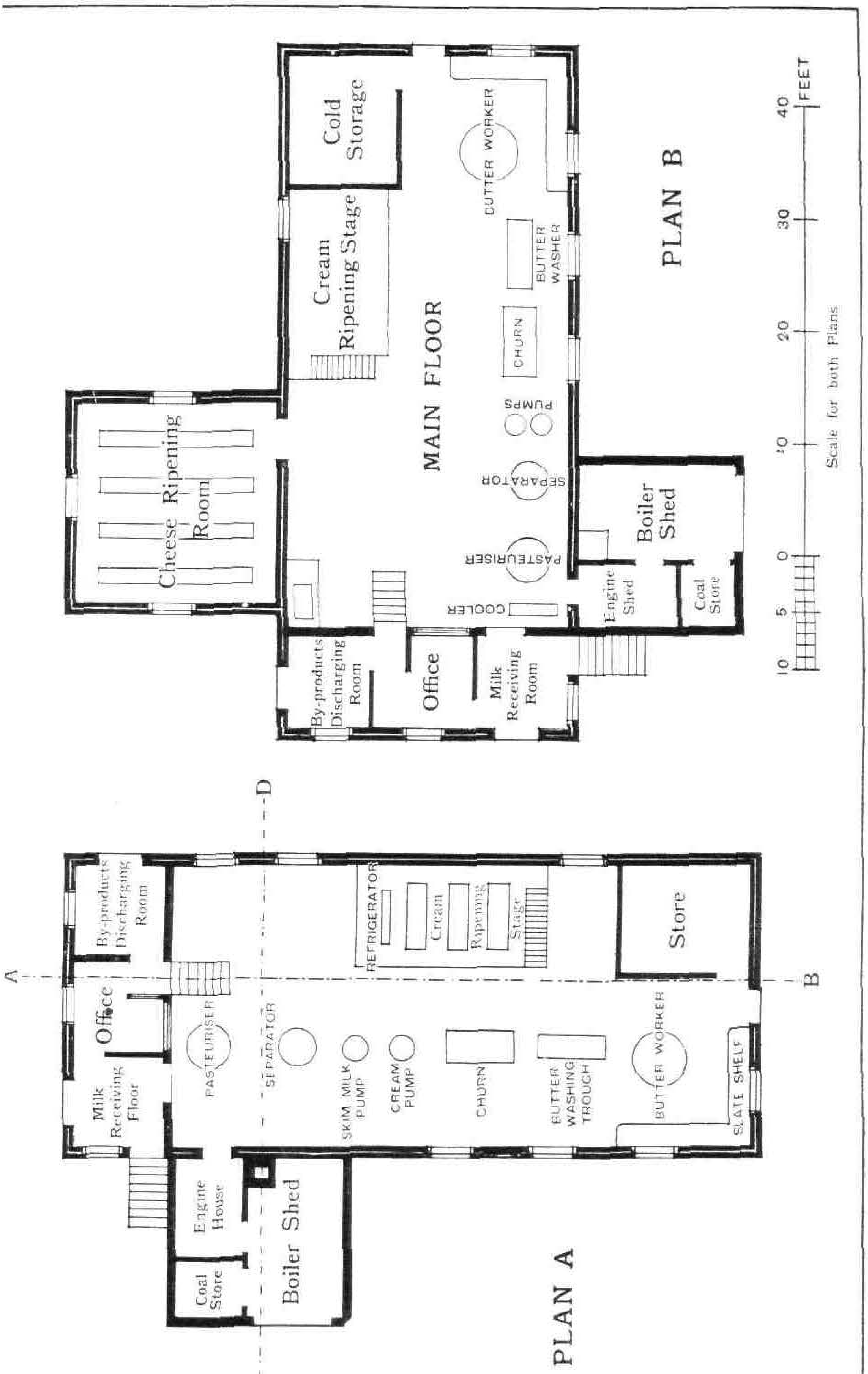
Plate III shows a milk-receiving depot, where milk is received and despatched without conversion into either cheese or butter. It is simply a collecting centre for the convenience of the farmers of any district on the one hand, and that of the milk-supplying agent or agency in town on the other. It may happen occasionally that the agent is for a time overstocked with milk and can find no outlet for any from some of the collecting centres. To meet cases of this sort it is wise to provide for the casual conversion of the milk into cheese or butter. In this plan, provision is made for the manufacture of cheese at times when it becomes imperative to do so.

The building is simple. The ground floor is taken up with the hall or general-purpose room. This is 3 ft. above the level of the ground outside—for convenience in discharging milk cans from the farms and delivering others being sent to town. The hall communicates at one corner of the upper end with the room in which the cans are scalded and washed. Here, too, the full cans are delivered by the farmers and sent up to the first floor by means of a hoist. And as the empties are sent down they are steamed and cleansed, and returned to the farmers. At the other corner there is access to the room where cheesemaking is prosecuted. There also is the stair leading to the first floor. Between these two rooms is situated what may either serve as a cold store or a place of the kind for general purposes. Upstairs come the office or manager's room, the milk-receiving room, and the cheese-ripening room. As with the other plans, the boiler house is a lean-to against the side of the main building. Steam is only required for scalding of cans, for heating water, and for heating the office and the cheese-ripening room, there being no demand for power as in the other instances. In consequence an engine may be dispensed with. In order to avoid pumping, the first floor is placed 10 ft. above the level of the ground floor. This difference enables the milk to be passed through refrigerators and be filled into the cans that are to be despatched to town.

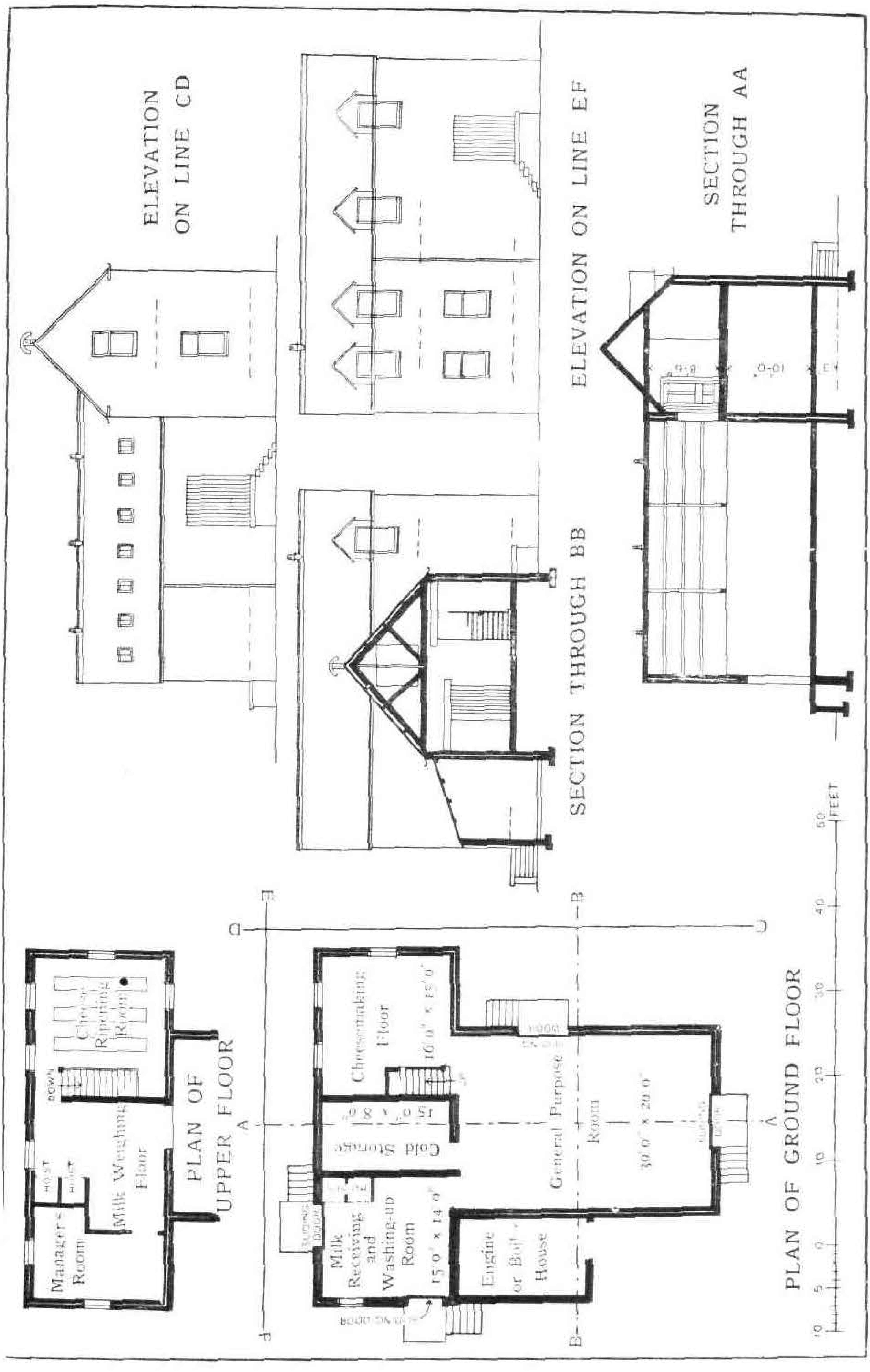
Each of the plans is of course open to more or less modification in accordance with local circumstances as regards supply of milk available and the nature of the site. No one can prepare a plan that will suit all manner of circumstances. It may be that in one case either the general-purpose room or some other of the places can be done with less in size than the plan shows. On the other hand, more room may be required.

The work is not finished when the building is erected. There are drains and roads to construct, and a water supply to provide. [R. H.]

Fæces consist of the solid and liquid excreta of animals and human beings. Animal fæces vary in composition according to the kind of animal, its age, and composition of its food, the proportion and kind of litter used, and upon the method of storage. Farmyard manure is composed principally of the fæces of farm animals with the litter. Fæces contain nitrogen, phosphorus, and potash compounds. These, along with the organic matter, make one of the most valuable of manures. The manurial constituents in the liquid fæces are in a more available



A, PLAN OF BUTTERMAKING FACTORY. B, PLAN OF CHEESEMAKING FACTORY



PLANS, ELEVATIONS, AND SECTIONS OF MILK-RECEIVING DEPOT

form than in the solid. However, by the action of bacteria and ferments the insoluble manurial constituents in both are slowly rendered available. [R. A. B.]

Fæces, Retention of.—There are many causes for retention of fæcal matter; some of them confined to a limited area of the canal, as when a dung ball or calculus blocks the way, and others to more distant ones, as when the liver fails to pour its secretion into the bowel; hence the desirability of seeking the cause in each case of retention, rather than resort to any special class of aperient medicine. The most common source of hardened and retained ordure is unsuitable food, as when animals are compelled to browse upon dry hillsides affording but little that is succulent, and offering much temptation in the way of woody fibre and other innutritious substances, which first satisfy the desire for distension, and then create it; a morbid appetite being established, and engorgement following. Paralysis of the muscular layer of the intestine supervenes, and the hardened mass cannot be extruded from the rectum. Any part of the gut may be thus blocked, but more generally the terminal portion. Sudden change from grass to dry fodder is calculated to produce constipation, as the secretions do not have time to accommodate themselves to the change; a change which is demonstrated by the fact that it takes a larger dose of aloes to purge a horse whose bowels are already soft at pasture than it does in the case of one stabled on hay and corn, and having but an occasional mash of bran or other laxative. If the transition is not too abrupt the gastric, pancreatic, and hepatic fluids are altered in character to suit the new conditions. No doubt the custom, once general, of physicking animals generally on going out to and coming in from grass, in spring and autumn, had its origin in the observed benefit conferred, the secretions receiving a direct impetus in the required direction. *Treatment*, then, will be directed to removal of the cause, and a liver stimulant such as calomel and aloes given to the horse or beast whose membranes have an unhealthy hue, and whose mouth has a sour odour or pasty tongue. For the horse, ruminant, or pig, packed with dry fibrous material, a strong aperient is not so suitable as repeated doses of linseed oil wherewith to soften the mass; but in the case of dogs there is no better draught than the popular one of equal parts of castor oil and syrup of buckthorn. In the case of the latter animal, fæcal retention is quite generally confined to the rectum, where the mineral elements of bones accumulate after the gelatinous portion has been absorbed. For dogs and pigs, the clyster of soap and water or warm oil is specially useful. Horses derive advantage from mechanical unloading of the rectum, or back-raking as it is generally called, after which a similar injection finds its way farther into the canal. Some assistance is derived from enemata in cattle and sheep, but ruminants bear large saline doses in much water. Without resort to drenching with active cathartics, constipation may in many cases be overcome by the judicious admixture of linseed oil, treacle, bran, pulped roots, and the green tops of brassicas if no grass can be cut. [H. L.]

Faggoting is the term applied to making little bundles or 'faggots' for fuel out of small branchwood and ends, in order to utilize the minor lop and top of trees and the small stuff that remains after coppice fellings have been assorted into the customary local classes (poles, hurdle wood, &c.). The size of faggots varies locally, but those of about 3 ft. in girth cost about 10*d.* a score to make, and sell for about 2*s.* a score. In olden times it was usually a full yard long and 2 ft. in girth. [J. N.]

Fagopyrum, a genus of the nat. ord. Polygonaceæ, which includes the Common Buckwheat, Tartarian Buckwheat, and Notch-seeded Buckwheat. See BUCKWHEAT.

Fairs. See MARKETS AND FAIRS.

Fairy Rings.—This name is given to the dark-green rings of grass about 1 ft. wide sometimes found on poor pastures; as a rule the rings gradually spread outwards and leave the inner grass more impoverished than before. The soil just outside the ring is found to contain the mycelium of certain fungi, usually the Hymenomycetes *Clitocybe nebularis*, Batsch, *Hydnum suaveolens*, Scop., *Marasmius sp.*, *Tricholoma gambosum*, and some Ascomycetes (*Spathularia*) and Bovists. Analyses made by Lawes, Gilbert, and Warington[1] showed that the development of the ring was accompanied by a loss of carbon and nitrogen, although on the ring itself there is a larger amount of nitrate than outside. Their results are:—

	Outside the Ring.	On the Ring.	Inside the Ring.
Carbon, per cent ...	3·30	2·99	2·78
Nitrogen, per cent ...	·281	·266	·247
Nitrogen as nitrate, per cent	·00024	·00115	·00010

The decrease in percentage amount of carbon and of nitrogen corresponds to a loss per acre of several hundred pounds of the latter and several thousand pounds of the former, so that the process is to be regarded as very wasteful and injurious.

The first rational hypothesis to explain the appearance of the rings was put forward early in the 19th century, and was based on De Candolle's theory, then generally accepted, that plants excrete substances poisonous to themselves but harmless or even beneficial to other varieties. The spore of the fungus having somehow got on to the grass, developed, and the mycelium spread; it excreted a substance which inhibited any further growth on the same spot, so that further growth could only take place outwards, and the inner part of the ring could not subsequently become infested. The excretion was, however, highly beneficial to grass, hence the fungus was immediately followed by a vigorous grass development. Later on, De Candolle's theory became discredited, and Way[2] suggested a chemical explanation almost the same as the one now accepted. He analysed the fungus and found that it contained a large

[1] Trans. Chem. Soc. 1883, vol. xliii, p. 208.
[2] Journ. Roy. Agric. Soc. 1847, vol. vii, p. 549.

quantity of nitrogen, potash, and phosphoric acid. When the fungus dies, all this stored-up foodstuff becomes available for the plant; the dead fungus is a manure, and causes the vigorous growth on the ring. Way laid more stress on the effect of the potash and phosphoric acid than on the nitrogen, but Lawes, Gilbert, and Warington showed by their analyses quoted above that the manurial effect was due to the nitrates produced, a fact which is also indicated by the dark-green appearance of the ring. Their view, which is now generally accepted, is that the fungus attacks the organic matter in the soil, assimilating some of the nitrogen, but causing also a considerable loss of carbon and nitrogen. When, subsequently, the fungus decays, its nitrogenous matter decomposes and is more readily converted into nitrates than is the original organic matter of the soil.

The loss of nitrogen caused by the fungi is a serious matter, and attempts have been made to eradicate fairy rings from pasture land. Since the rings are of most frequent occurrence on poor pastures, it has been suggested that the best method of eradication is to improve the pasture by manuring, feeding, &c. Experiments made in New South Wales by G. H. Robinson[1] showed that the fungi were entirely killed by watering the ground with ferrous sulphate solution, 8 lb. dissolved in 50 gal. being applied to each 60 sq. yd. The application was repeated four times at intervals of one week, and then lime was applied at the rate of 1 ton an acre. This method would no doubt be too costly for agricultural purposes, but it is the only direct method that has proved successful. [E. J. R.]

Falconry, the art of training falcons to hunt winged or small ground game. See HAWKING.

Falcons.—Like other birds of prey these forms chiefly subsist on mice and other small rodents, and are so far beneficial. They also destroy small birds, both of useful and harmful species. There are two native forms requiring notice, *i.e.* the Peregrine and the Kestrel. (1) The Peregrine Falcon (*Falco peregrinus*) is about 16 in. long, the male being rather smaller than the female. It breeds in late March or early April on a cliff ledge, or it may be in the deserted nest of a rook or crow. The four yellowish eggs are shaded with orange or reddish-brown. It undoubtedly helps to keep down small rodents, but also preys on sea fowl, pigeons, and small singing birds, these last being mostly beneficial. Game and poultry are also attacked. It may be said in general that the good done outweighs the harm, except under special circumstances. (2) The Kestrel or Windhover (*Falco tinnunculus*) is decidedly smaller than the preceding, but its nesting habits are similar, though the breeding season is later (end of April). The six eggs are usually of a rich-red colour, but are sometimes paler, with dark-red blotches. The Kestrel feeds almost entirely on rodents, small birds, beetles, and grasshoppers. According to most observers it is decidedly beneficial to agriculture, and does not merit persecution. [J. R. A. D.]

Fall, the term used to denote the slope or declivity in drains, ditches, or watercourses. A measure of land equal to 1 pole or perch is also called a fall.

Fallow implies a period of rest or recuperation for land. The word is of Saxon origin, and, as an adjective, means pale-red or pale-yellow, hence fallow deer. This application of the word is naturally explained by the pale-red or yellow colour of ploughed land after exposure to the bleaching and drying effects of the sun and wind. It graphically describes the appearance of a fallow field in contrast with cropped land, and refers especially to what we term bare fallow. In modern agriculture, 'fallow' includes various systems of cultivation of a renovating character, such as the substitution for naked fallows, of 'roots' for consumption upon the land, or of green or fodder crops, to be ploughed in, or eaten by live stock. The various descriptions of fallow may be classified for convenience as follows:—

1. Bare or summer fallows.
2. Root-crop fallows.
3. Green-, or fodder-crop fallows.
4. Half, or bastard fallows.

These modifications have all the same object in view, namely the renovation of the land for the growth of corn or other exhausting crops. This preparation involves freeing the land from weeds, and restoring its fertility by exposure to atmospheric agencies, as well as by direct manuring. The bare fallow is the oldest of these systems, and is frequently referred to in Leviticus and by the Prophets, who attached an allegorical meaning to the process. The land was to 'enjoy her Sabbaths', and fallow or idle 'ground' was to be broken up in a moral sense. The original idea appears to have been that of complete vacation, and this would suggest tillage, for freeing the land from weeds, and for sowing. Systematic fallowing was understood at a very early period, and appears to have been introduced into southern Britain by the Romans, but only at a comparatively modern date into Scotland, where it has never been in high favour.

The alternative of simple rest, or the abandonment of soil to natural pasturage, has always existed side by side with systematic fallowing. It was practised even in the last century in backward districts in England, and may be still employed in a slovenly and semi-conscious manner. It consists in allowing foul land to lie idle after a period of corn growing, and to remain under natural herbage for a sufficient period to restore its fertility, when it is again broken up and cropped. Such is the crude system followed in new countries in which agriculture is practised without regard to the teachings of science. It constitutes a sort of rough rotation, alternating between corn and grass, or periods of depletion and renovation, and is instructive as showing the natural recuperative power of soils.

The theory of fallowing depends upon the existence of plant food in every soil, in two forms. These have been termed soluble and insoluble, available and potential, active and dormant. These expressions mean that plant food, in order to be available, must be soluble in water; and that exhaustion only means an in-

[1] Journ. Bd. of Agric. 1907, p. 537.

sufficient supply of soluble plant food. The process of solution is gradually effected by moisture, the action of frost, and other atmospheric forces, which act upon the insoluble plant food in the soil and render it available. The amount of soluble plant food in even fertile soils is extremely small, although widely distributed. If, for example, a soil contains ·1 per cent of phosphoric acid, the amount available may only amount to ·01. In the case of potash, ·004 per cent, available, has been found sufficient for the requirements of a growing crop.

It is the object of fallowing to restore the normal proportion of available plant food through natural solution, aided by systematic tillage. The process is accelerated by exposing fresh surfaces to the air, and what might require several years of rest may be accomplished in a single season by repeated cultivations. Strictly speaking, fallowing draws upon the magazine of potential plant food in the soil, and, so far, it must tend to ultimate exhaustion. It is, however, sometimes the practice to lime and manure fallows, so that the land becomes enriched by direct additions of fertilizing matter, as well as by the conversion of insoluble plant food into the soluble state. We have outlived the notion that land requires 'rest', for such an idea is inconsistent with root cultivation. Roots are more exhausting than corn, as they require much larger supplies of all the principal constituents of plant food. Land requires feeding, and does not demand rest. The bare fallow induces the natural accumulation of soluble plant food, and affords an opportunity for liberal manuring.

The substitution of root crops for the older system is consistent with all the objects of fallowing. In the first place, root crops are sown in the summer or late spring, thus allowing an interval of at least seven months for tillage and cleaning between harvest and the season for sowing. Secondly, they are, and certainly always ought to be, liberally manured. Thirdly, they are singled, hand-hoed, and horse-hoed; and the land is thus kept clean. Lastly, they are fed upon the land or on the farm, in most cases with liberal additions of purchased food. They therefore fulfil the conditions required, and, in fact, prove more than an equivalent for bare fallowing. Root crops have taken the place of bare fallows on all the lighter classes of land, and further encroachments have been made upon the fallow area of clay lands by the introduction of mangel wurzel, rape, kale, and cabbages, all of which are suitable for stiff soils. The bare fallow is restricted to clay-land districts, and holds its place in the estimation of many expert farmers, especially in England. The area under this system of cultivation at the present time is about 300,000 ac. in England, but only 7000 ac. in Scotland, and it prevails for the most part in those counties which are situated on the great Clay formations.

The reasons for the survival of bare fallowing are not always satisfactory, and become less evident from decade to decade. Thorough drainage, steam cultivation, the introduction of new fodder crops, and the necessity for economy, all tend to diminish the area of idle land. On the other hand, certain classes of soil produce heavier wheat crops after bare fallowing than after roots, and these latter are notoriously uncertain and expensive to produce on such soils. There is consequently a residuum which is subjected to the oldfashioned plan.

Next, as to green crops, grown for fallowing purposes, or for what is above described as half, bastard, or *rag* fallowing.

These may be illustrated by the growth of winter vetches sown upon wheat stubbles, and subsequently removed from, or fed upon, the land. The ground is then ploughed, and worked into a proper condition for wheat, which concludes the work. This system may be applied to clover and grass seeds, first mown for hay, and then broken up, rag fallowed, and put into wheat. On light soils a variety of so-called 'catch crops' (which see) are often sown after harvest, such as trifolium, winter rye, winter barley, and vetches, and, after being consumed by sheep, the fold is broken up for roots. This is a fallowing system under which sheep are twice passed over the land. It is practised largely on the light soils of the Chalk formation, and results in heavy corn crops even on thin, poor soils.

The ploughing-in of green crops, such as white mustard, lupins, vetches, &c., effects a double purpose, as it both manures and cleans the land. Mustard grows very fast under suitable conditions, and three crops may be sown and ploughed under during one summer. The luxuriant growth smothers Couch and other weeds, while the mass of vegetable matter enriches the soil. Green-crop manuring has been a favourite theme with many writers, and is worthy of attention. There is some advantage in ploughing-in a fodder crop, as the entire mass is returned to the soil; whereas if eaten by sheep, a certain proportion is retained by the animals. This by no means disposes of the question, as sheep are often allowed extra food, and in other cases are run on adjacent land and folded on the fallow. It is, however, clear that, so far as the crop itself is concerned, all its manurial properties are returned intact to the soil when it is ploughed-in.

Bare fallows, as already mentioned, are restricted to the stiffest descriptions of land, and the cultivations are modified accordingly. These consist in cleaning, pulverizing, and aërating (sweetening) the soil. They are best accomplished by repeated ploughings, in some cases as many as nine, but more ordinarily five are given. These ploughings are named, or were named in days when bare fallowing was more general, as follows:—

1. 'Fellying', or fallowing out of stubble, in February.

2. Running back, or reversing the furrow, in April or May.

3. Cross ploughing, in June or July.

This brings the land up in large rough clods, which are harrowed (dragged) and turned over repeatedly.

4. First gathering, or ploughing into 3- or 4-yd. ridges.

This is followed by the application of dung.

5. Seed furrow, or second gathering.

This should be concluded in August, and the land is then ready for sowing.

The land should be worked in such a manner as to expose rough clods to the action of the midsummer sun, in order to roast or bake the soil, and thus effect the destruction of every green thing. The clods crumble down under the dressings, and the changes of temperature and conditions of moisture, and by seedtime the fallow should consist of a mixture of fine soil, suitable for germination of the wheat, and clods lying on the surface. During winter these clods fall over the young wheat and prevent its being 'thrown out', *i.e.* the exposure of the rootlets to the weather.

In Essex as many as nine ploughings were formerly given, but the introduction of steam power and the necessity for economizing labour have altered the routine considerably. It is not too much to say that the systematic working of fallows is less arduous and less guided by prescription than formerly, when precise directions were prescribed in farm agreements as to the number of ploughings and the manner in which they were to be given.

A fallow, in some form, is still looked upon as a necessity—that is, a period of renovation and cleaning after a series of exhausting crops has been taken. That a root crop during its growth is actually more exhausting than a corn crop is inconsistent with the idea of rest. The restoration of the roots to the land disposes to some extent of this difficulty, but if they are drawn off the field, they cannot fail to exhaust the soil. To grow roots successfully they must be liberally treated, and the general effect of their cultivation is no doubt renovating. Still, there are problems in connection with soil exhaustion which are yet unsolved; but there appears to be no scientific reason why the application of fertilizers should not enable corn crops to be grown in succession, without the intervention of bare fallows, or even of root fallows. The cleaning of the land is so important that it alone seems to justify a fallow at intervals. The treading of sheep is also beneficial on light soils, and so much is this the case that, on such soils, corn seems to require a previous folding. On the heavier and stiffer soils the advantage of folding is less evident, and even disappears, or becomes injurious, and it is upon such soils that continuous corn cropping (or the continuous growth of saleable crops) may be carried out successfully, with the aid of fertilizers.

In ordinary practice the interval between fallows varies from three to eight years. It is the recurrence of the fallow at regular intervals which marks off each rotation and completes each course. Thus the old three-field course consisted of bare fallow, wheat, and beans or oats. The four-course rotation involves roots (fallow), barley, clover, and wheat; and a five-course is arrived at either by leaving the clover down a second year, or by tacking on an additional corn crop after the wheat. See ROTATIONS. [J. WR.]

Fallow Deer.—It is doubtful whether the Fallow Deer (*Cervus dama*, Linn.) can be accounted truly indigenous in the United Kingdom. In the Pleistocene age this genus existed in England in common with the rest of western Europe, but it is now only to be found undoubtedly wild in Spain and Portugal, the Cevennes Mountains, the Alps of Dauphiné, Rhodes, Greece, Sardinia, Persia, and northern Palestine (Millais's Mammals, iii, 140).

In Great Britain there are at the present day upwards of four hundred royal or private parks where fallow deer are kept, some of these enclosures dating from very early times; and herds of these animals in a wild state exist in the New Forest, Epping Forest, and Rockingham Forest. In the present state of our knowledge it is impossible to decide whether these are descended from an original indigenous stock. The probability is that the fallow deer of the Pleistocene age did not survive the second glacial period in Britain; otherwise their remains would have been discovered where those of red deer, the roe, and the giant fallow deer (commonly called the Irish elk) are so abundant, namely in peat mosses and riverine deposits. For practical purposes, however, fallow deer have become as closely identified with our native fauna as pheasants, and would establish themselves in all suitable places were they allowed to do so. They have done so in the valley of the Tay, where they were introduced about a hundred years ago; and they are also to be found in various parts of Sutherland and Argyll, and in the south-west of Ireland. But the presence of such large and destructive ground game cannot be tolerated in the neighbourhood of cultivation, nor is the constitution of fallow deer sufficiently robust to enable them, like red deer, to take refuge in the mountains.

Fallow deer belong to the Damine group of the Cervidæ, in which the upper incisors and canines are wanting. In colour they are very variable, but in the normal type the coat in summer is light-reddish-brown with large white spots, whence the name 'fallow', from the Anglo-Saxon *fealu*, *fealo*, signifying the colour of ploughed land. On the other hand, 'fawn', the young of the fallow, has lent its name to denote a pale warm brown. The neck is greyish-brown, sometimes spotted with white. A white horizontal line passes along the lower part of the ribs, and a black line along the spine from the crest to the end of rather a long tail, branching out at the root of the tail to encircle the white rump. The throat, chest, belly, and inner surfaces of the limbs are white, or nearly so. In winter the white spots vanish and the coat assumes a uniform brownish-grey, very dark in some animals, lighter in others. White fallow deer are not uncommon; there is also a melanic type, verging to black, and every shade of variety occurs between the two extremes. The iris is hazel, and the horns have conspicuous *bur* and *tray*, but usually no *bay*, becoming palmate towards the extremity, with several points on the margin and a back point on each horn.

The following terms have been long in use to distinguish fallow deer by sex and age, being familiar in Shakspere's day:—

Male.		Female.	
First year	... a fawn.	First year	... a fawn.
Second year	... a pricket.	Second year	... a tegg.
Third year	... a sorel.	Third year and after	... a doe.
Fourth year	... a sore.		
Fifth year and after	... a buck.		

The sexes of red deer and their young are spoken of as hart or stag, hind and calf; those of fallow deer as buck, doe, and fawn. It is reckoned a great solecism to interchange these terms.

The size of fallow deer depends much upon food and exposure. A good buck should stand about 37 in. high at the shoulder, measure about 68 in. from nose to tip of tail, and weigh about 10 st. clean; but in good parks they get very fat, and Mr. Millais records the following top weights from the three kingdoms: Scotland, Drumlanrig, 18 st.; England, Petworth, 16 st.; Ireland, Colebrooke, 15 st. 3 lb. (Mammals, iii, 137). The finest head he ever saw was carried by a buck at Petworth in Sussex, the length of horn being 29½ in., circumference of beam 5 in., breadth between tips 17 in., and points 27 in number.

Calving begins in June. The bucks cast their horns in May the older animals first, the prickets following in June. They are clear of velvet in August, but it is not till October that their necks begin to swell, and at the end of that month the advent of the rutting season is announced by the bucks 'belling', or making a sound aptly described by Mr. Millais as something between a prolonged grunt and a bark. They fight fiercely for the does, but the encounter seldom ends fatally, as it often does in a duel between red stags, the antlers of the fallow buck being much less formidable weapons than those of the stag. Bucks are not often dangerous to human beings at this season, though it is prudent to be prepared for exceptions, as when a hairdresser called Sadler was attacked by a buck in Greenwich Park in November, 1905, and died of the injuries he received.

As beasts of the chase, fallow deer are said to be more difficult of approach when truly wild than are red deer, and this has been the cause of their survival in the New Forest. They were strictly preserved there till the middle of the 19th century, when Parliament, in response to complaints by farmers and owners of common rights, decreed their abolition, reserving at the same time 10,000 ac. for planting. A great slaughter of deer took place in consequence, but the keepers failed to extirpate them. A few always managed to find refuge in the woodlands adjoining the Forest, enough to provide sport with a pack of hounds which Mr. Lovell had formed to assist in the work of extermination. As time went on, the 10,000 ac. of plantation grew up to make a secure harbour for the deer, and by this means a sufficient number have been preserved to provide sport with hounds every spring and autumn.

The so-called Irish Elk (*Cervus megaceros*, Hart) is now recognized as a gigantic fallow deer, which, though long extinct everywhere, survived from Pleistocene times as a contemporary with man, in some parts, at least, of the United Kingdom. None of the Cervidæ on the earth at the present time come near this splendid creature in bulk and stature. The male stood from 6½ to 7 ft. high at the shoulder, and carried enormous antlers, many of which have been recovered measuring each upwards of 6 ft. long with a beam 13 in. in circumference and 18 to 28 points, the palmated ends being sometimes 24 in. in width. From tip to tip the spread of the antlers is as much as 9 ft. 5 in. It is amazing to think of the prodigious vitality and strength and the amount of sustenance required, to enable a creature to grow and cast annually these enormous appendages. Perfect skeletons have been recovered from lacustrine deposits in Ireland and the Isle of Man; remains have also been found in the south of Scotland, but they are very rare and badly preserved in the English river gravels. [H. M.]

False Acacia. See Acacia.

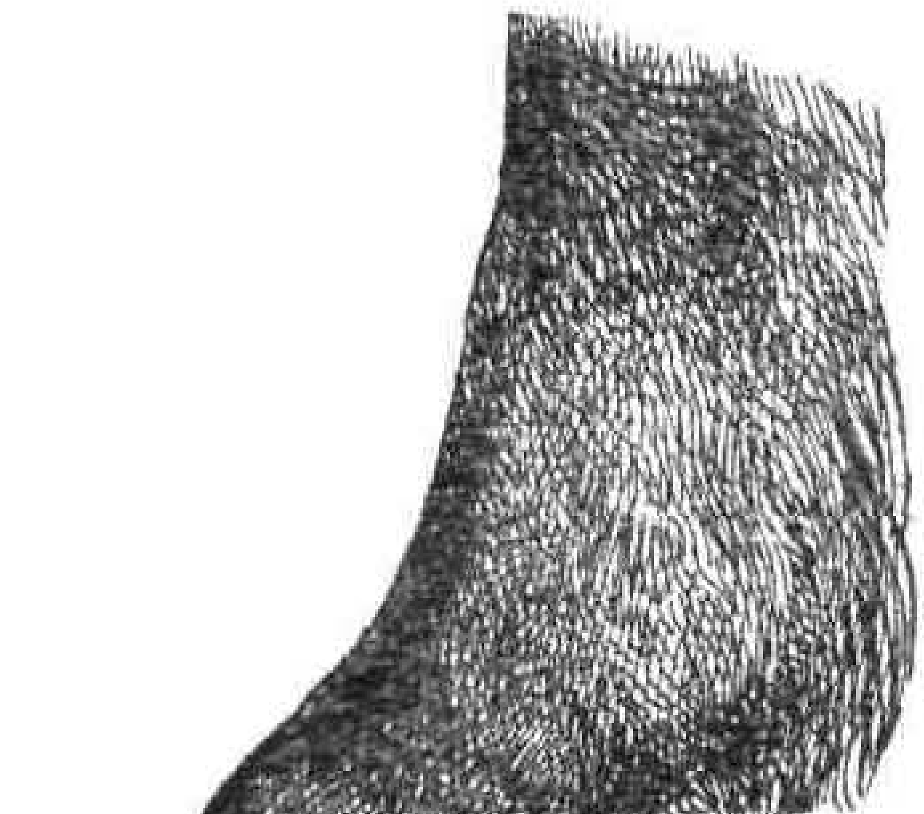
False Brome, a creeping perennial grass belonging to the genus Brachypodium. See Brachypodium.

False Gid, a malady in sheep produced by the larvæ of the Sheep Nasal Bot (*Œstrus ovis*). The constant irritation and immense suffering caused by the presence of these grubs in the nasal passages produces symptoms closely allied to those of Sturdy or Gid, and hence the name 'False Gid'.

False Heath. See Fabiana.

False Oat Grass, a tall perennial fibrous-rooted grass somewhat resembling the oat in external appearance, and hence the name 'False Oat'. See Arrhenatherum.

False Quarter.—The term 'false quarter' is applied to a horse's foot in which such a



False Quarter

serious injury has occurred to the horn-secreting band (coronet) as to leave a permanent division or deep fissure running from top to bottom of the hoof wall. The new horn on each side of the fossa is more or less imperfect, and the wall less resistant to external injury or concussion on hard roads. Although a certain amount of

accommodation is reached, and in the case of long upright feet much useful work is possible, a horse with false quarter is unsound and an undesirable purchase. The presence of false quarter may be attributed in most instances to quittor, or tread, frostbite, or other violence sufficient to destroy the horn-secreting papillæ. A bar shoe affords protection against separation, and ring leathers reduce concussion and are therefore recommended. There is no radical cure, as the defect is due to loss of structure and substitution of other material. [H. L.]

Fan Barley, a two-rowed barley belonging to the race *Hordeum sativum distichon.* See BARLEY.

Fanner. See WINNOWING MACHINE.

Farcy.—Farcy is now recognized as a form or variety of glanders (see GLANDERS), and it is desirable for owners to know this and avoid misunderstandings with the local authorities, to whom notice must be given as with the other form of glanders. Farcy sometimes takes an acute form with corded swellings of the lymphatic vessels in a limb or limbs, and with much constitutional disturbance; or with less active symptoms remains chronic. In both cases there are characteristic swellings, known as 'buds' and containing matter.

It is unfortunate that inflammatory œdema, or 'Monday morning leg', called also 'weed' and a 'shot of grease', should too have been called farcy, or water farcy, as the latter has no connection with it, although resembling acute farcy in the sudden and painful swelling of the limb. The buds are not present, and should distinguish the one from the other. A confused nomenclature results from the fact that horse doctors were formerly uneducated men, although many were very useful in their day. [H. L.]

Fardel Bound.—The third stomach or compartment of the stomach in ruminants, called fardel, farthing, maniplies, and omasum, besides some other names of quite local application, is liable to become impacted with dry innutritious substances and bring about acute indigestion. When a shortage of hay corresponds with low prices for imported maize, and the latter is too freely substituted, much disease of the kind results. In dry summers and on rough pastures, cattle make up in bulk what they lack in quality, and in the absence of sufficient water, the ailment called Fardel Bound is a not infrequent penalty. Loss of cud is the first prominent symptom, then constipation, and in the case of cows, loss of milk. The animal assumes a wooden attitude, standing for a long time in a listless way, and as if stiff all over, grinds its teeth, and emits a grunt at the end of each expiration. Suitable treatment is usually successful, unless Fardel Bound is connected with other digestive difficulties or specific diseases. Small doses of linseed or castor oil at frequent short intervals are preferred to the more powerfully cathartic action of aloes, but the latter drug is still much esteemed for the purpose by oldfashioned practitioners, and given in doses of 1 to 3 oz., with $\frac{1}{2}$ to 1 lb. of salts, and large volumes of water. [H. L.]

Farina or **Potato Starch** is obtained from the tubers of the potato, which contain about 20 per cent of starch and 75 per cent of water. The starch exists as minute grains in the large starch cells, the cell walls of which have to be broken before the grains can be washed out. The potato skin contains some fat and colouring matter, but no starch. The extraction of starch from the potato forms a very important industry.

To obtain the starch, the tubers are first carefully washed to get rid of sand and adhering dirt. This is generally done in a revolving wire drum, inside of which are revolving wire or bristle brushes, which both scrub and rub the potatoes together as the drum turns. The dirt is carried away by sprays of running water. After cleansing, the tubers are placed in a machine, where they are rasped and lacerated by revolving knife edges or scrapers.

The pulp formed consists of starch and cellulose fibre. It is placed in a series of shaking sieves, and the starch washed out with fine jets of running water. The milky liquor is further passed through a sieve with 50 meshes to the linear inch, for retaining any fibre. The starch suspended in the wash water is then run into tanks, where it is allowed to settle. The heavy material with any sand separates out first. Different grades of starch are got according to the purity.

The pulp is dried and pressed, then used as cattle food. Potato starch is sometimes obtained by the 'rotting process'. In this process the sliced potato is kept in a warm room; fermentation soon starts, whereby the cell walls decompose. This allows the starch grains to be readily washed out. The starch is separated and purified by the same method as described above. In this process much care is necessary that the fermentation does not attack the starch.

The wash water from potato starch is rich in potash, phosphates, and albuminous matter, and is in consequence of manurial value.

Farina or potato starch has a glistening white appearance, and has a crisp feeling when pressed between the fingers. Examined under a microscope it will be seen to consist of minute grains, round in shape, with concentric markings. It contains from 16 to 20 per cent of water. It is used largely for sizing, and produces when boiled in water a thicker paste than any other starch, consequently it is more economical than other starches for making starch paste. It is said that farina induces mildew in cotton goods to a smaller extent than any other starch, because of the small amount of nitrogenous matter it contains. It is also used in preference to other starches for the manufacture of British gum. Farina contains about 83 per cent of starch. [R. A. B.]

Farm, Desirable and Undesirable.—The character, situation, and tenure of a farm are all important considerations in connection with its profitable occupation. However skilful the management, it is often found impossible to farm to a profit, if the conditions are unfavourable. It is an axiom among practical men that rent is of secondary importance if the land is good and the holding desirable; and this feeling

is indicated by the frequent expression of opinion that it is better to pay a high rent for good land than no rent for bad land. A low rent is no doubt an important concession, and there are many cases, especially on large properties, where rents are intentionally low, and fixed upon a basis suitable to prices even in bad times. A distinction should be made between bad land and poor land, for the former is always to be avoided, and in these days has in many cases passed out of cultivation. Poor land may possess many of the virtues of poverty. It may be grateful and responsive to benefits conferred, and capable of producing heavy crops under good management. Such crops are, however, maintained at a high level at a considerable and constant expenditure, and it is evident that this is practically equivalent to a rent. On the other hand, good land will stand severe cropping without heavy outlay, and therefore may be as cheap as low-rented land.

The productive power of land represents its quality, but its character depends upon its degree of stiffness or retentiveness. Rich clay land is certainly desirable, but so also is rich light land. Of the two classes, a light or medium soil is preferable, as entailing less expense and less risk. A rich loam, suitable for potatoes, roots, corn, and clover, which will stand sheep folding is more profitable than a stiff clay of equal productive power. A high proportion of grass land is also desirable in these days, say one-third or one-half of the total area, as tending to reduce the labour bill (both manual and horse), and to render milk production possible.

To be desirable, a farm must be well situated, and this expression is more comprehensive than might at first appear. It means that the land should lie favourably for the reception of sunlight, *i.e.* slope to the south, south-east, or south-west (see Exposure); that it should not be elevated too highly above the sea level—not more, for example, than 600 to 800 ft.; that it should be level or gently undulating, and free from precipitous or steep gradients, and that it should be well supplied with water.

These may be regarded as natural advantages, but there are others equally important, but accidental rather than due to nature. Among these may be mentioned the following considerations, the absence of any of which would be enough to condemn a holding. First there must be a sufficient supply of labour within reasonable distance; second, good roads, railways, and facilities for marketing produce; third, ample cottage accommodation for resident farm servants; fourth, well-arranged and modern farm buildings; and last, but not least, a good house. In the same category may be included good fences, free watercourses, and good farm roads. If the reader imagines a farm grossly deficient in any one of these points, he will at once perceive that the holding could not be desirable unless taken at a nominal rent.

Size of Holding.—Large arable farms are mostly found in light-land districts, and are often associated with sheep-farming. They are, presumably, naturally drained, and healthy sound sheep land. The rents are low, and range from 5*s.* per acre up to three or four times that amount, according to their situation and quality. They often include some good low-lying pastures fitted for cows, and the produce consists of sheep, wool, corn, and milk. If well situated these farms are certainly desirable, and are generally occupied by prosperous tenants. Such are the chalk farms of Yorkshire, Lincolnshire, and the southern counties, often over 1000 ac. in extent.

Clay land, if not too stiff in character, is well adapted for potato cultivation, and produces good crops of all kinds. It is also an excellent basis for permanent pasture, and is better adapted for Shorthorns and other well-bred cattle than light land. Clay farms are usually of smaller size than the previous class, being often of 150 to 300 ac. in extent. They require special knowledge as to tillage and management, but in good hands may prove desirable holdings.

In selecting a farm, all the above points should be kept in view, but, in addition to them, information should be obtained upon the following points:—

(1) The amount of the annual payments in the form of rates, rural and urban, educational and sanitary, sea walls or embankments, or other burdens of an unexpected and unusual character. (2) The custom of the estate with reference to game preservation and sporting rights, which as far as possible should be retained in the hands of the tenant. This is not unreasonable in the case of farms at a distance from the landlord's residence.

From what has been stated, desirability in a holding seems to be summarized as the aggregate of characters possessed by land of moderate or good quality, fairly rented, well equipped, well watered, well situated, safe-cropping, neither too heavy nor too light, and not subject to excessive rating. [J. Wr.]

Farm Accounts. See Accounts.

Farm Buildings. See Buildings, Farm.

Farmer.—The position and the work of the farmer differ widely in different parts of the kingdom. In places he is a producer of grain, hay, and stock. Elsewhere he is largely a stock-breeder or a feeder. In certain districts dairying or sheep-farming is the staple industry. Many farmers give a fair amount of attention to hops or hard or soft fruit, potatoes or poultry. Some do a great deal of work in seed production; others have gone in for a sort of market gardening. It is recognized that within recent years the kind of farming followed in some districts has changed; in others it is obviously in process of change. It is not only the kind of stock and crop that are found to be different as we journey through the kingdom; methods of husbandry and the technology are also dissimilar. Barns, for instance, which are used in some parts for corn—a word, by the way, which does not mean the same thing all over the country—are in other places utilized for the storage of hay. The phrase, 'the custom of the county', illustrates how sectional farming practice is in this country. It is no doubt the complicated geological history of Great Britain which is responsible in no small degree for differences in farming ways. The work of a farmer obviously

varies a great deal according to the size of his holding. There are farmers who have hardly any labour beyond that of their own families. Others have enough land to keep them almost all day in the saddle; yet others find it necessary to employ an overseer or a bailiff. One thing, however, all farmers have in common, and that is the need of a long training on the land. The novice should not draw a false impression from the fact that the agricultural colleges, before awarding their certificates, specify that the candidate shall have spent a certain amount of time on a farm. Other experience of farming, beyond such incidental acquaintance with it, is imperative. Within recent years the opportunities of scientific instruction put in the way of those who would enter farming have been greatly extended and cheapened. Information on this head may be obtained on application to the various agricultural colleges and other centres of agricultural instruction. (See EDUCATION, AGRICULTURAL.) Every year the necessity grows for such scientific training, either at colleges or winter schools, or by home reading. No man can farm intelligently nowadays who has not some acquaintance with the elements of agricultural geology, botany, chemistry, and bacteriology, while the value of a certain acquaintance with animal physiology and pathology is patent. Nevertheless, men with no scientific knowledge have farmed with a large measure of success. Their returns might have been larger, however, had they had some science at their disposal. Artificial manures cannot be applied to the land, nor can feedingstuffs be used in the most economical way, without a knowledge of the why and wherefore. In the choice and use of implements and machinery, in which recent years have seen such improvements, technical knowledge also comes in useful. A knowledge of science is of special value when the conditions of farming are changing. Some acquaintance with the scientific facts which underlie successful manuring, feeding, and tillage are not only of the first importance economically, but add immensely to the interest of the work of the agriculturist. Farming, when rightly followed, can be made perfectly satisfying as an intellectual pursuit. Those who do not see to it that the younger generation of farmers is encouraged to seek scientific education incur a grave responsibility. The country districts can never be what they might be, unless those concerned in rural industrial pursuits find them sufficient not only from a financial but from an intellectual point of view. No one desires to deny the farmer recreation in the ordinary sense of the word, but his daily work rightly understood should not only be a means of making money, but furnish him with an absorbing interest in life. Many extreme things have been written about the necessity of scientific knowledge; the true motto of the farmer is that of the Royal Agricultural Society, 'Practice with science'. In order to be successful it is necessary for a farmer not only to have practical knowledge, along with as much scientific knowledge as he can obtain, but for him to have the qualifications of a business man. Material though the losses may be through a farming practice which may be behind the times, or lack scientific knowledge, or be subject to unfavourable weather conditions, they cannot be greater than the losses which may be experienced through an inability to buy or sell well. It is little good growing fine crops or producing fine stock if the work is done too expensively or if the crops of stock cannot be sold to advantage. A farmer, whatever else he is, must be under present commercial conditions a good trader. He must also be a business man in the administration of his farm. He must further have the knack of managing men. And, of course, he must cherish an affection for country life, and be content to live long and laborious days. ['H. C.']

Farming.—The attractions of the oldest industry are obvious. At the worst the farmer has a very large proportion of his food, not a little of his firing, and a comfortable home. Even when his income is small he is able to live in a position of some dignity. His house stands in its own grounds, he has people to work for him, and he has a horse and trap. Beyond this, he lives largely an open-air life, and he is his own master. If he cares for sport he can indulge it inexpensively, and he can be hospitable without a heavy drain on his resources. It is no wonder that, contemplating all these attractions of the farmer's life, the townsman should often be envious of it. He fails, of course, to see the other side of the picture. The best will and the best knowledge fail in farming when the weather is unpropitious. The management of farm hands, of land and of stock, calls for a high degree of skill and constant watchfulness. Frequently a large capital is bringing in an inconsiderable rate of interest. Recent legislation and a more enlightened custom of the county; measures directed towards making the labouring class more satisfied with its position, and more equal to it; invention and scientific discovery, and improved facilities for buying and selling are doing much to ease the farmer's task. But the farming business remains one of no little difficulty. Thousands of well-intentioned business people from the towns, who loved the country and had money to lay out, have failed to show a financial return on their farming. It is a profession in which those who follow it must learn early and be always learning. It is rare to meet anyone who is not a farmer who fully realizes the demands made on the knowledge, skill, and character of those engaged in agriculture. Like all businesses, it has been affected by the competition of countries which, for various reasons, have been able to produce its commodities more cheaply. But the circumstances in which farmers carry on their business—in many cases imperfectly capitalized; remote from one another and unaccustomed to the use of some of the machinery by which business men in cities keep in touch with progress; little given, as a class, to reading much or to literary expression; disposed by the teachings of long experience to be slow to change their methods, and hereditarily inclined to rely on the counsel of a landed class, which has too often,

perhaps, unduly exalted the value of State assistance—have prevented agriculturists moving as rapidly with the times as some urban industries, so placed as to be more alert. Nevertheless, the farming of Great Britain is a business with more capital in it than is common in much of the farming of the Continent, and, as the produce returns bear witness, the yields here are in advance of the countries which are sometimes held up, a little indiscriminately, as examples. A visit to one of the great societies' shows, an acquaintance with the number of agricultural societies in existence, and with the value of the meat and milk produced and of the stock exported, also help to bring home the high degree of efficiency attained by the agricultural industry. That there is scope, however, for the further application of business principles seems to be proved. But what is commonly overlooked by business men who prescribe the business methods of town enterprises for rural industry is that in farming it is impossible to organize things on a factory basis; there must always be an element of give and take, due to the weather and the human factor. It is impossible, again, for the most business-like and well-capitalized farmer to go into the details in his bookkeeping, which can be reached with no great difficulty in manufacturing concerns. The exact cost of some operations and of certain produce cannot be exactly set down because it cannot be ascertained. But many farmers might advantageously do more bookkeeping. There are other farmers who, not merely by a more enterprising expenditure, but by putting themselves in touch with the most up-to-date methods, might obtain better returns. This applies not only to manures, feedingstuffs, and stock and machinery, but to management; in the matter of buildings, the relation of tenant and landlord complicates matters. Although in many districts the most economical methods of buying and selling are still to seek, farming, in the hands of the efficient and the adequately financed, does not return, under reasonable conditions, a less satisfactory dividend on capital than the average of industrial pursuits; and if it is a business entailing more anxiety than many others, it is also one of many attractions, lasting interest, and no little honour. See also FARMING, SYSTEMS OF. ['H. C.']

Farming, Systems of.—

ARABLE CATTLE-FARMING

Just as summer grazing is associated with pasturage, so is the winter fattening of cattle inseparably connected with arable land. On all light soils, suitable for folding, sheep are to be preferred to cattle; but on strong lands, which are injured rather than benefited by treading, and are also particularly improved in texture by applications of farmyard manure, beef production takes the place of sheep-farming. The winter grazing of cattle is an important feature in mixed farming, but in some cases it occupies such a commanding position as to stamp itself as the principal feature of the business. The advantages of winter grazing of cattle are inferior to those of sheep fattening, because the expenses are heavier, while, strange as it may appear, at the same time the value of beef has for many years been considerably lower than that of mutton. Cattle require housing and litter, besides more individual attention, and are consequently more expensive to maintain than sheep. The conclusion therefore appears inevitable, that wherever sheep can be substituted for cattle they will be preferred. On the other hand, in situations where folding is injurious to the land, and, as is usually the case, farmyard manure is thought necessary to mitigate its stiffness, cattle fattening will be resorted to. In this connection the reader may find it interesting to refer to the article below on 'Continuous Corn Growing', as land of stiff character might possibly pay better if more exclusively devoted to corn, with the aid of artificial manures, than to cattle fattening in winter. The system of manuring through dung is, however, deeply rooted in the minds, and we may almost say in the affections, of farmers. No one can say that farmyard manure is not the best possible application for stiff land, just as sheep manuring is allowed to be the best for light soils; and the consequence is that both systems are firmly established. The manure produced is the best apology for carrying out a system which in itself is alleged to be carried out at a direct loss, or rather expense.

The value of dung is incalculable, because no one has yet limited the length of time during which it continues to act. The late Dr. Anderson of Glasgow rated it as highly as 12*s.* per ton. On the other hand, 5*s.* per ton is a more ordinary estimate of its value. If it were not for the manure, cattle fattening on arable land would certainly entail a loss, and the system must therefore be regarded as a means of keeping up the fertility of land. This conclusion may be considered as sound, with the exception of cases in which the cattle are particularly well bought and sold.

The haulage of roots, and their cleaning and preparation, and the carting back of manure to the land, are serious items, as is also the waste of both food and fertilizing matter, all of which are obviated by sheep folding.

In examining the systems of winter cattle feeding employed, the root crop is an important consideration. In Scotland and the north of England these crops are not only abundant but of high quality, and are capable of fattening cattle alone, or with very little assistance. Straw is also in many cases unmarketable, and of higher nutrient value in the north than it is in hotter climates. Turnips and straw constitute the principal feeding materials in Scotland, and have often been declared to be the cheapest available foods. On a diet of roots and straw, aided by moderate amounts of cake and meal, it is possible that cattle fattening may be profitable, and it is significant that in Scotland the number of bullocks fed varies principally with the bulk of the root crop. In the southern counties of England neither roots nor straw can be depended upon to anything like the same degree (mangel-wurzel excepted), and the system of feeding assumes a much more artificial and

expensive character. It involves chaff-cutting, pulping, and a larger proportion of artificial foods, and is less likely to prove directly remunerative. The effect of an abundant root crop upon the prospects of cattle feeders is double-edged, for it was once remarked by a Norfolk agriculturist that three good root crops in succession would ruin any grazier, the idea being that the higher prices for store stock consequent upon good-keep prospects, would eat up all the profits from fattening.

The dubious results obtained from cattle fattening in winter have induced many graziers to alter their practice in favour of cow-keeping, and the laying away of land to pasture. The case may be readily stated, and is as follows. Tillages are expensive, and the price of wheat has failed to supply the remuneration which at one time might naturally be expected. Laying land down to grass abolishes both these disabilities, and at the same time opens a prospect of selling milk at an immediate profit. This is in all respects more advantageous than bullock feeding, for it must be remembered that even if the former is so conducted as to be profitable, the profits must necessarily be deferred until the manure has had time to act on future crops. Manure produced in winter cannot yield a profit for at least a year, while the roots and straw required in the process run backwards into another year. It therefore appears fairly evident that the winter grazing of cattle is to be ranked among the less profitable systems of agriculture, and must tend to disappear in favour of sheep-farming wherever practicable, cow-keeping, and permanent pastures.

Arable cattle-farming may easily assume the character of dairying, and much has been written upon this aspect of the subject. Tillage land is unquestionably of great assistance where a large herd of cows are kept, and in some cases the area of pasture may be comparatively small. Such crops as mangel-wurzel, cabbages, vetches, lucerne, &c., may be grown for milk production, and corn cannot be dispensed with on account of the straw. The object would be to leave fattening alone, and devote the produce of the farm to milking-cows, and in many cases the change would be beneficial.

Cows make excellent use of their food, and the milk is a constant source of ready cash. It is generally allowed that milk selling is profitable, if only because it appears safe from foreign competition, and, we must hope, from the error of over-production. A system of arable-land dairying is therefore worthy of attention and encouragement. [J. Wr.]

Carse-land Farming

Cultivation of the low-lying clayey alluvial soils of Scotland, or the carse lands as they are termed, is work which demands special training. Field operations have to be well timed, because the success not only of a single crop but of a rotation depends so very largely on the condition of the soil at times of ploughing, harrowing, and seeding. North of the Border no classes of land have fallen so much in rent since the prosperous 'sixties and early 'seventies of the past century as have the retentive clays of Gowrie and Stirling, Lower Strathearn, and Berwickshire. In popular language, such tracts have been almost killed by expense of production, and low prices for produce. Working of the flat clays is not only directly slow and toilsome; it is restricted in a special degree by the nature of the weather. That adds to expense of cultivation. On light friable soils with a fair slope and suitable roads, two pairs of horses are generally quite sufficient for 120 to 130 ac. cropped in a five- or six-course rotation with one section under roots, but on a typical carse farm two pairs are rather overweighted with 100 ac.

In the Carse of Gowrie the standard rotation for the genuine clay is an eight-course, which works out as follows: (1) Summer fallow, (2) wheat, (3) beans, (4) wheat, (5) green crop (mostly swedes and turnips), (6) barley (sown down), (7) hay, (8) oats. The best wheat almost as a rule is after fallow which has been kept well stirred and clean during the long days. At an odd time the 'bean wheat', however, is the bulkier and better of the two. That may happen as result of an early season. If the bean crop is off the land by the end of September, ploughing of the bean stubble is overtaken under the best possible conditions, and seeding is finished with the proper amount of moisture in the ground. Should October and November be extremely wet, fall sowing of wheat after beans runs risks of disaster through attacks of slugs. Cautious men, therefore, hold off and wait till spring for seeding down with oats.

Hand-sowing is still much practised on the strong carse lands, because a man can frequently step out in the mornings and overtake his work quite well, while the sowing machine may not act with perfect freedom until the day is far advanced. On the clay also, a smart shower is apt to clog the machine for a short time. As a general rule, beans are ploughed in with a moderate furrow, so far as the Carse of Gowrie is concerned, and it is seldom that the wheat stubble has had any dressing except fifteen to twenty loads of fresh dung in autumn or well-rotted dung in spring—the spring treatment having the almost regular preference. On the clays the preparation of the land for green crops is specially trying and laborious when a mild winter is followed by a wet spring. Rapid transitions from wetness to drought are also prone to throw ordinary methods of calculation out of gear. Little good can be done under such conditions. When a good shower comes to the relief, work is once more attacked with vigour. It is rather the exception to see regular brairds of swedes or common turnips all over the carse lands of Scotland. The rule is to find partial failures as results of first sowing. Should Scotch clay-land swedes come through the summer without much stinting, they frequently develop into very good crops, and it falls to be said that yellow turnips continue to grow on carse land several weeks longer than the loamy soil average. On the clay, however, the feeding value of the roots can never be put as first-class.

Carse-land barley is usually bulky in straw, 'bold' in grain, and up to a fairly high standard in quarters per acre. The sample is not so bright as that from thin sharp soils which are not overdone with manure, and broadly put, its best outlet is towards distilling, in which department it ranks rather under the product from the best early coast-side loamy soils. For production of high-class stable hay the carse lands of Scotland are unexcelled. In Gowrie, rye grasses and mixed clovers are the regular blend. The rye grass is mainly perennial, and the clovers are mostly the Red and Dutch varieties. Oats of the Potato and Hamilton varieties, which thrive so well on loamy soils, are quite unsuitable for clays, as they tend to 'sedge' on the latter, but many other varieties—two or three of the old and several of the new—are profitable on the carse lands, and produce ample bulk of straw along with plenty of grain.

Most of the Carse of Stirling land is not so stiff as the average of the Gowrie expanse. Still, sections of the soil near the windings of the Forth are of a sticky, difficult nature to handle. The Carse of Stirling specializes considerably in growing timothy hay and mashlam (beans and oats mixed). The ordinary rotation is: (1) Oats, (2) fallow or green crop, (3) wheat, (4) beans, (5) barley (sown down), (6) rye grass and clover hay. The bare summer fallow is, of course, taken on sections of very stiff land. In place of the rye grass and clover hay there may be timothy, which is allowed to lie down for four or five years. It is topdressed at the fall, and yields the heaviest of the hay crops when properly managed. When the timothy break is ploughed up, the sowing is with oats; then come beans or mashlam, followed again by oats, the succeeding break being fallow or green crop.

Although the carse lands of Scotland are generally classed as clays, they contain loamy sections which are quite easily wrought. In the neighbourhood of Errol, for instance, there are sections of very fine deep loam over bands of gravel. A farm which contains the two classes of soil is wrought in separate courses. The ordinary rotation for the loam is a six—three sections in grain, one in potatoes, one in turnips, and one in hay. Some prefer a seven. In that case they cut little if any hay, but take two years pasture. On the clay they follow the usual eight-course.

The all-clay holding in the carse-land district is not for a man with stock-breeding predilections, but it produces great bulk of winter feeding. In most cases, carse-land farmers have reasonable freedom in selling off straw and turnips, but those who farm high prefer to keep a full stock of cattle in winter and spring, and to sell their surplus of wheat straw. The wintered cattle are either sold off in forward condition at the beginning of the grazing season, or finished as fat animals between spring and early summer. Carse-land farming gives ample scope for judgment and energy. Its existing disadvantages, even in face of moderate rents, are heavy working expenses and low prices for produce.

[J. CA.]

Cattle-grazing Farming

The Grazier is always associated with the fattening of cattle on grass. He may be a raiser of young stock, or a keeper of dairy cattle; but these occupations may be carried on upon an inferior class of pastures, and the distinctive character of grazing is confined to beef production in summer. It can only be prosecuted upon land and herbage of rich character, and is therefore confined to certain districts and counties. There is little of this class of farming in Scotland, on account of the prevalence of tillage, and the comparatively small proportion of high-class grazing land. South of the Border it is followed in every county in some degree, and becomes associated with 'mixed farming', a system to which separate attention has been given. The degree of richness of the pastures controls the class of cattle used for the purpose of fattening, and only the choicest land is capable of fattening large steers, as will be presently shown. Smaller cattle and heifers will fatten upon pastures a degree less rich, and Irish heifers and hard Highlanders or Galloways will make themselves fat even on ordinary dairy land. In order to obtain the best results, mature cattle above three years old are preferred to those which have not accomplished their growth.

There are good fattening pastures in Northumberland, on the seaboard and scattered over the interior. Also in all the northern counties, including Durham, which is not remarkable for rich land. The following counties need only be mentioned to agriculturists in order to be recognized for their grazing lands: Yorkshire, in its dales and warp lands bordering on the Humber and other warp-laden rivers; Lincolnshire, with its marshes; Norfolk, with its broads; Essex, with its marshes; and Kent, including Romney Marsh. It would be tedious to enumerate all the situations favourable for this class of farming, but a few notable cases may be cited as indicating the principal grazing districts. Northampton is a famous county for grazing, as are also Leicestershire, Warwickshire, Bucks, North Wilts, Salop, Stafford, Cheshire, Gloucestershire, and, pre-eminently, Somersetshire, Devonshire, and Worcestershire. Ireland, both on account of her soil and climate, is a great grazing country, and boasts the possession of some of the finest pastures in the United Kingdom.

Turning to the geological features of grazing districts, good pastures occur on every formation, but mostly upon the great Clay beds, and the 'masked' or superficial layers left by the action of tides, rivers, drift, or lava deposits of remote geological date. The clays already mentioned include the London, Kimmeridge, Lias, and Boulder Clays. The Lias especially forms a broad belt extending through the midlands from Yorkshire to Somersetshire, where it mingles with flat alluvial tracts of great richness. In many of these districts there is scarcely any tillage land, and they are all known as great hunting centres, as, for example, Rugby, Melton-Mowbray, and Leicestershire generally.

The herbage is generally of mixed character,

and the quality of the grazing depends in a great measure upon the rich, deep, and retentive character of the soil.

Grazing has always been regarded as a highly remunerative pursuit, and graziers have been customarily classed among the more opulent members of society. Fortunate is the man who holds extensive grazings of this class, for such lands are not easy to obtain, as they are tenaciously held. They have been unaffected by the fall in the values of wheat or other grains, although they may suffer from fluctuations in the price of store cattle and of beef, as well as from adverse seasons. Labour is as nothing, and all costs of tillage, seed, harvesting, threshing, &c., which overload the arable farmer, are absent. The gross proceeds are principally divided between the landlord and the tenant, and as they rival and exceed the value of the produce of tillage land, it is easy to see that the share to each of these partners must be considerable. This result is not looked upon with favour by philanthropists and political economists, but this does not prevent it from offering an excellent investment for capital. The occupation demands skill, but does not make nearly the same demands upon the occupier's time, nor does it require the same varied knowledge as arable farming. Regarded *per se* it is not exactly agriculture in a strict sense, because it does not involve the cultivation of the field, and is better described as a pastoral industry. The researches of chemists and the inventions of engineers affect it little, and book-knowledge is less useful than a clear judgment as to the class and condition of the cattle needed, and a close attention to markets. The shifting of stock from pasture to pasture and the judicious use of artificial foods, form important parts of the knowledge of graziers.

The principal season extends from about the middle of April to the middle of September, or over a period of twenty weeks. It varies according to the peculiarities of the season, being sometimes postponed to early May, and extended into October, at which time of year the grass loses its 'nature'. There is a period of rest, or freedom from stock, after the spring grass has become exhausted, followed by a growth of fall grass. Gravelly pastures yield the earliest grass, and the colder and deeper pastures are later, but hold out better during the height of summer.

The quality of the land influences the stage of forwardness of the bullocks purchased. The best, or finishing, land is adapted for bullocks in forward condition, after liberal feeding in winter. Such animals are too often sold at a sacrifice, but this is the grazier's opportunity, as such cattle will become prime beef in a few weeks, and may be passed on to make room for others. Cattle which are half-fat may be purchased off land of poorer quality, and finished on first-class land with great advantage, as they not only increase in weight, but in value per stone.

It has been already stated that the gross returns of grazing exceed those of most tillage lands, while the expenses are much less. This is readily shown to be the case by the progress which bullocks make on really good land. This has been estimated at 14 lb. of beef per head per week, which may be fairly valued at 7*s*. per stone. If this is realized during twenty weeks, as was assumed to be the case by that indefatigable statistician the late Mr. J. C. Morton, the return would amount to £7 per acre if a bullock to the acre is maintained. Mr. Morton put it at a bullock and a sheep to the acre during twenty weeks, and added £1 for winter grazing. Perhaps this estimate is a little high, but it might apply to very favourable cases. We must not forget the dearthful period about midsummer, when even the best pasture may be brown for several weeks. Twenty weeks is, however, a short period out of the entire year, and it is probable that £6 per acre is commonly taken off good grazing land. The ordinary agricultural rent is not heavy, and varies from 30*s*. to 60*s*. per acre, which apparently leaves a substantial profit to the tenant. Good grazing land in the neighbourhood of towns often lets at £5 to £7 per acre for accommodation purposes, and the writer has known water meadows (which are scarcely equal in quality to the best pastures) let at £7 per acre for the season, with the right of removing the hay crop. It must be good agricultural land which will under ordinary courses of cropping throw back a gross return of £6 per acre, against which must be placed a formidable list of unavoidable expenses which have been already indicated. The capital required for stocking land of this quality is apparently large, but need not necessarily be so, as the period during which it is needed is short. Three and six months accommodation bills would meet the case on occasions when money is scarce, and large dealers will accommodate good customers if protected by a lien on the cattle. Otherwise it is clear that one bullock an acre means £13 to £20 per acre capital, which is considerably more than is necessary for even high-class tillage land thoroughly well stocked and equipped.

The management of a large grazing farm is not so complicated, nor is it so fertile a theme for a writer, as the management of arable land. There are, however, certain axioms connected with grazing which must be attended to in order to ensure success.

1. The stock must be adapted to the land, the herbage, and the climate; and on no account should cattle be purchased from richer and warmer situations.

2. Overstocking is to be shunned, first because it is important that grazing cattle should not be stinted as regards food, and secondly, because in case of a drought and scarcity of keep, prices are liable to fall. This places the overstocked grazier in a very unenviable position. On the other hand, if understocked he will not be obliged to sell, and may buy at great advantage should the opportunity occur.

3. Pastures ought not to be stocked too soon, nor until there is a good bite of grass.

4. Once in the season they should be cleared of fattening stock. They should then be closely eaten down by less forward or leaner animals, or by sheep, in order to promote a uniform growth of the later grass.

5. The running up of grasses into flower should be avoided as far as possible.

6. A portion will be reserved for hay, according to the requirements of the holding.

7. All pastures should be brush harrowed and rolled in the spring, and it is also recommended to spread the droppings of cattle when they accumulate on the surface.

8. Cake is often supplied to grazing cattle, and may be placed in troughs, or scattered over the ground for the cattle to lick up. Rock salt is also frequently given in boxes.

9. Water is a very important adjunct to a grazing farm, and it is a great advantage to have a stream, or natural source of water, available for the cattle at all times.

Dishorning is sometimes practised, as it is found that this deprivation renders the cattle more docile, and they are said to fatten more kindly afterwards. As to other equipment, much depends upon the proportion of tillage land on the farm. It is seldom that a grazing farm consists entirely of grass land, and a little tillage is certainly advantageous. It enables the grazier to grow cabbages, turnips, mangel, and straw. In periods of scarcity, roots or cabbages can be thrown out upon the bare pastures, and cattle, not yet ripe for sale, may be brought in and finished in the winter. Or, less forward animals may be held over, and turned out to be finished on grass in the spring. A proportion of tillage land involves buildings, implements, and horses, but when these requirements pass beyond certain limits, the character of the farming is altered, and grazing becomes part of a system of mixed husbandry. [J. Wr.]

Chalk-land Farming

The cultivation of a farm of which the subsoil is chalk, which sometimes rises very near to the surface, is largely associated with a breeding flock of sheep. These farms are often very large, owing to the fact that they chiefly consist of down land, which it is impossible to cultivate through the medium of the plough. Where the soil on the surface is fairly deep, as in the valleys, arable farming is not only possible but quite common, and in consequence a large head of stock can be fed and fed well. On the downs, such as those of Sussex, Wilts, and Hampshire, where the soil is very thin, the land is chiefly confined to the grazing of the flock during the summer season; but it is a curious fact, which hardly applies to any other class of soil, that little or no attempt is made by the majority of down farmers to induce the herbage to grow in greater abundance where the soil is thin; in a word, it is simply impossible to manure a sheep down with the dung of the farm, while the extensive area which it so often covers prevents the farmer using artificials for the purpose, not because it would not pay him, but, as we must suppose, because the expenditure would be a large one.

Sheep, then, are one of the chief staple products of the chalk-land farm. Where the plough is used, crops are grown which not only feed the sheep with advantage and economy, but which improve the soil as well, and prepare it for the production of grain crops in the rotation which is followed, as well as root and forage crops for the flock itself. On a chalk-down sheep-farm the work is followed in a cycle as well as in a combination. For example, the sheep are fed upon special crops, as we shall presently show, in combination with cake and corn, with the result that the land is manured, not only with the manure produced from the crops consumed, but with that resulting from the cake and corn. If oats or barley follow, they are enabled to grow owing to the manure produced within the sheepfold, and where clover or sainfoin are sown across the corn crop they are helped as well, and produce crops in the following year. When a root crop follows corn, it is manured with farmyard dung and artificials, which chiefly consist of phosphates in an acid form, and if the dressing is generous a good crop of turnips is obtained. These in turn are consumed by the sheep, folded day and night, and again supplied with cake and corn, so that the following grain crop is provided not only with the residue of the cake and corn, but with the phosphates supplied to help the turnips, which have been consumed and chiefly returned to the soil in the manure.

Two of the most important breeds among English sheep are the Southdowns, whose home is in Sussex, and the Hampshires, which are kept so largely in the adjoining counties of Hants and Wilts. These sheep are largely fed upon the downs, and upon the adjacent fields of deeper tilth, which not only produce crops for their consumption, such as turnips, sainfoin, and clover, but sometimes vetches, rape, cabbage, trifolium, and grain as well. Thus the produce grown for the market chiefly consists of the grain crops and the sheep, the former going to market, especially from Hampshire, in the shape of lamb.

There are many parts of England in which farming is conducted upon a soil with chalk below it, and yet in many cases it becomes essential to lime the land. Sometimes the chalk is very deep, as in the Weald of Sussex and part of Surrey, forming as it were a basin between the North and the South Downs. Chalk-land farming, however, is practised from Kent to Dorset, including the Isle of Wight; north of London it is quite common in some parts of Hertfordshire and Bucks, and is an institution on the wolds of Lincoln and of Yorks. In some of the southern districts, as in the midlands and the north on hills of a different formation, farmers occupy land which, like the downs themselves, is warm and dry, and therefore healthy for the flock. On a south-country sheep-farm of this type the farmer has an advantage over his neighbour in the north, inasmuch as he is able to produce a larger variety of crops, some of which, like maize and *Trifolium incarnatum*, are annual, and both cheaply and easily grown; but he also grows rape and mustard, or rape alone, thousand heads, cabbage, turnips and swedes, and in many cases lucerne, which is often cut four times a year, and which remains until it is overcome by weeds after lying down from six to seven years.

A chalk farm, unless it be rich in tilth, not only requires liberal management, but abundant stock that it may be well manured, for it easily goes back, and in a very short space of time fails to pay its way, unless it be in the valleys and in those parts of the holding where the soil approximates to an average loam. These soils are extremely prolific, and are advantageous to the farmer, both as useful for stock of almost every type, and for growing crops upon almost any system which applies to loam. On soils like these it is not essential to follow any purely chalk-land system of rotation, for by good management, which includes the generous feeding of the soil, the tenant can do almost as he likes. A soil which will grow clover and other plants of the Leguminosæ is in a good position to achieve success, for where these plants grow with certainty and luxuriance the soil is easily provided with the most important of all manurial constituents, nitrogen; indeed there is perhaps no form of manure which is so essential to a chalk soil as that which is rich in this constituent. Chalks of one description must of necessity be supplied with phosphates. This will be easily understood when we look at the nature of their origin; but there are other chalks which are very ill-supplied, and which must be continually fed with organic matter in the form of dung from the foldyard, or from the droppings of the sheep which are folded upon them for the purpose. But for the special system adopted by the chalk-land farmer these soils would be practically sterile; by the employment of manure, as has been already suggested, to which superphosphate has been added, root crops, clovers, and their fellow tribesmen can be grown, and the more abundantly they are fed the greater the luxuriance, and in consequence they will feed a larger flock of sheep, which, in turn, will provide more manure. Chalks of this class are therefore dependent upon the golden hoof of sheep, but we are bound to add that they are also dependent, and that very largely, upon artificial manures. In far too many cases it is impossible to keep sufficient head of cattle on a chalk farm to provide dung for liberal distribution.

We take the case of a large sheep-farmer who has done splendid work, and who, in our recollection, added to his farm some 200 ac. of land which had been practically abandoned and which was covered with weeds. The rent was a nominal one after the first year or two, but the land was quickly cleaned and manured, the large flocks of the owner assisting in the operation of reclaiming it. In due course it became equal to the rest of his farm of similar character, and has undoubtedly by this time fed off for the butcher many thousands of lambs. In such a case the process is simple, for owing to the thinness of the soil it lends itself to summer fallow, and can be tilled with any of the implements of the farm at almost all seasons of the year. And here lies one of the great advantages of the chalk farm. It is the custom of some tenants to complain of its hungry nature and its continuous demand, but it provides the farmer with one advantage—his horses can be almost continuously at work a few hours after heavy rain, unless, as in some particular cases, the chalk is of that type which is sticky and obnoxious during wet, while baking hard in the sun. Such farms, however, are not of the class of which we speak in these remarks. On farms like that to which we have referred, the crops which are grown are numerous, practically including all the varieties already named, in addition to oats and barley on the thinner soils, and wheat where the tilth is deeper, growing in rotation with mangels, cabbages, and clover, and, as occasion may require, with lucerne, which revels in a soil of deep character.

Where a portion of a chalky farm has been neglected, it is by no means difficult to recognize its type by the flora—or shall we say, the weeds—which grow upon it. These almost invariably include plants of the Leguminosæ,—such as vetches and trefoils of uncultivated varieties—burnet, and one or two grasses among the bromes and avenas.

We have noticed that on some of the slopes of the Southern Downs the plough is creeping upwards, and that land which in our recollection of forty years ago was under grass, on which the public rambled while the sheep were feeding, is now growing roots and corn. Nor is there any reason why much more chalk-down land should not be broken up where the surface soil is deep enough to till. Oxen are still employed for draught in parts of Sussex, especially between Brighton and Eastbourne, where there are tiny villages almost solely consisting of a church, a parsonage, and a farm, with a group of cottages nestling in the hollow between two mighty downs. We have chiefly referred to the feeding crops which are grown for sheep, but they are also grown for cattle, inasmuch as the hill grazing is too poor to produce sufficient size. Except in Sussex, where the County Reds are most in favour, cattle of various breeds are fed in yards and sheds for beef, and on many farms they are chiefly sold at Christmas. On a chalk farm of one type the produce is confined in particular to sheep and barley—we speak of that which is marketed—although in many cases where clover, sainfoin, and grasses which are converted into hay are grown in quantity, a portion of these is sold as well. On farms, however, where a large portion of the area is deep and rich, the selling produce is less restricted, all kinds of grain and stock being grown for sale, realizing excellent prices. It is not every man who can take a chalk farm, inasmuch as we have seen that it demands some capital for investment in live stock and manure—indeed without plenty of sheep, down land is almost useless. But, as we have already shown, money is required to provide the crops which the flock needs in the winter, while without a flock the land upon which the arable crops are grown would scarcely grow any crops at all.

[J. Lo.]

Clay-land Farming in England

There are such a large number of Clay formations in England, and they are of such large area, that the farming of the soils on the same forms an important department of the agri-

culture of the country. The principal Clays are as follows: Lias, Oxford, Kimmeridge, Weald, Atherfield, Gault, London, Boulder, and Estuarine. Out of all these the only ones represented in Scotland are the Boulder Clay (Till) and the Estuarine Clay (Carse land), so that it can thus be easily seen that clay soils form a much larger proportion of the soils of the south than we meet with in the north, while the difference of climate and rainfall enforces differences of treatment.

Some of these formations are not of very great extent, but where the Oxford Clay and the Kimmeridge Clay come together we have one of the most extensive tracts of clay soil, running from Dorset to Yorkshire, and known as 'the Clays' of central England.

In bygone years, before underdrainage was introduced, and when surface drainage only could be practised, it was the custom to lay this land up into very high ridges or 'stetches', with deep furrows between, and in this way the water in a wet season was led off the top. The ridges were continually gathered to the one crown for autumn-sown crops, so that in the course of years these became very high. This system of ridge-and-furrow is entirely unsuited to modern farming and the use of improved implements, though quite passable in the days when everything was done by manual labour, and therefore we find all such fields allowed to go back into grass.

It will be readily understood why the greater part of such land is in permanent pasture, and that much that was in cultivation in old time when corn was a valuable crop has been laid down once more. The soil is so stiff that often it is 'three-horse land', that is, it requires three horses to pull the plough in ordinary work, while often the horses work in line in the furrow to prevent the trampling and poaching of the surface.

All these clay soils have been excessively difficult to drain. It is customary to lay pipe drains at a depth of from 2 to 3 ft., and a width between of from 15 ft. upwards in ordinary soils—even in the Boulder Clay soils, but in some of these thorough underground drainage has proved extremely difficult because of the adhesiveness and impermeability of the soil. Where underdrainage is practised the piping is laid at less than 15 ft. apart, and not more than 2½ ft. deep; if laid at a greater depth it does very little good.

The difficulty of draining is further increased by the level contours of the fields in many cases, it being often impossible to tell by the eye which way the ground 'falls', and the spirit level has to be called into use to determine which way the drainage is to go, while very careful work is necessary in bottoming and laying the pipes. On the lighter clays, where cultivation is still carried on, the land is usually laid up in narrow stetches of from 7 to 14 ft. wide, with an ordinary furrow between, and the implements are made to suit this 7-ft. width of work. The furrows and ridges change places every time the land is ploughed, but such a cutting up of the land is a nuisance, and it may be fairly asked if it would not be better to lay down to grass land that is so stiff as to require this excessive surface drainage.

The system of mole-draining is practised very extensively on clay lands, where there is a fair amount of fall to be had. The mole plough may be worked on a large scale with ploughing engines, or it may be pulled by a horse windlass. In any case the 'plough' consists of a frame carrying a large coulter, the bottom end of which is thickened out into a large cone or plug—the 'mole'. The coulter is set to any depth required, and the whole pulled through the soil. It leaves an open channel in the clay about 3 in. in diameter, and this will drain the soil and remain open and efficient for twenty or thirty years. As a rule each drain is made to discharge separately into the ditch at the bottom of the field, but they may be put into a 'leader' drain as in pipe-tile draining. To make it a success the clay must be homogeneous, as any sandy or gravelly spots would ruin the working of the drain, and there must be a good fall to ensure a good delivery of the water.

There has been a great tendency in recent years to sow down land to grass, and of course the first land to be so treated has been the stiffer clays. Indeed it may be asserted that all land so stiff that it is difficult and catchy to work, and requires extra horse strength, ought to be put into grass. Sowing down under such circumstances has generally been a great success when a suitable mixture has been used. The stronger and better grasses are most successful, while clovers, lucerne, &c., do well. The following is a typical prescription which has proved successful under several different conditions:—

	lb.
Cocksfoot ...	5
Perennial Rye Grass ...	8
Meadow Fescue ...	2
Timothy ...	2
Italian Rye Grass ...	3
Alsike ...	2
White Clover ...	2
Lucerne ...	6
Total per acre ...	30

For temporary purposes red clover alone is often grown for two cuts, and if 'sickness' is feared a little Italian rye grass may be added to make bulk.

In the arable cultivation of such land the great point is that a fallow crop or root crop is at a discount and may fail altogether, and the root crop that is most likely to succeed is the mangold.

The mangold is *par excellence* the root for a clay soil where it is loamy enough to grow roots at all. It refuses to yield heavy crops on the lighter soils unless heavily manured, but revels in a proportion of clay, while its powerful tap-root goes down deeply and gets its moisture in a dry time. It is of course a southern crop, as it is very susceptible to injury from frost, while sunny weather suits it, and therefore it will succeed on southern clays where turnips or swedes would be shrivelled up or become badly mildewed.

Cabbages, kail, and kohlrabi also do well on such soils when well manured, on account of their deep powerful roots penetrating below the influence of drought when the soil has been well prepared for them.

The bare fallow, however, is the cleaning 'crop' of the rotation on a clay soil, and much horse labour is expended on the same—sometimes as many as five ploughings, with a corresponding number of harrowings, rollings, &c., being carried out. Every living thing is killed out by being turned up and roasted by the sun, while at the same time the land is worked down into a beautiful state of tilth. The idea is to get all seeds of weeds in the soil to sprout and then be killed, though some prefer to keep their fallow in a cloddy or lumpy state in case too much rain should come.

A little rain will help the working of the fallows, but too much will spoil them, as the working of the soil would poach it into mud, while the weeds would grow instead of being killed. For this reason a dry sunny season is desirable, and for the same reason fallowing is most largely carried out in the sunnier regions of the south and east of England, where the rainfall is least. It may be thought by some that five ploughings are excessive, and that the passage of a cultivator through the soil would be as effective and more speedy, but experience has shown that while the cultivator does well enough sometimes, the plough is the best implement if the land is cloddy or rather too wet for proper working. If too cloddy it may be necessary to run the rib-roller over it to crack the clods and thus make its soil finer and more easily worked.

Bare fallowing at intervals was of course the rule all over the country in the olden time as the only means of cleaning and renovating the soil—the Mosaic law enforced it one year in seven—but the introduction of root crops quite altered the system of farming, and in the moister north and west quite superseded it, and bare fallowing in many districts is a thing long gone out of fashion. On these clay soils under a drier climate, however, root cropping is always more or less precarious, and therefore it is not surprising to find that the Agricultural Returns for Great Britain show in recent years a decrease in the root area, especially in the growth of turnips and swedes, though the area under mangolds has slightly increased.

Manurially, liming has been of the greatest value, more for the effect it has on the texture of the soil than as food for plants, and as in many cases the clay is actually a marl—that is, contains a large proportion of lime in it—the dressing of the surface with so many loads of marl per acre was an important permanent improvement in the olden time, and we see many marl pits or 'clay pits' dotted all over the fields in many districts, relics of the claying or marling which was largely carried on in former days. Any form of lime does good, and gaslime has been a favourite form where it could be procured in sufficient quantity, 3 tons per acre being applied to grass land up to 6 tons on arable land with benefit.

For direct manuring, of course, farmyard manure is one of the best dressings to give on the arable land, not so much on account of the small amount of fertilizing ingredients contained in it, but because its bulky organic material helps very greatly to improve the texture, friability, and other physical characteristics of the soil.

Insoluble artificial manures, with the exception of basic slag, do very little good, and especially do the various bone manures give no appreciable result; bone meal or 'quarter-inch' bones would be literally thrown away. But basic slag has the most pronounced influence, since not only does it stimulate the growth of clovers and other legumes on the pasture lands, but it has also quite as good an influence on roots and corn crops on the arable land. Soluble manures like superphosphate and nitrate of soda are also very effective.

On the very stiffest clays the simplest of all rotations is practised—wheat, beans, bare fallow. This fallowing not only kills all the weeds out, but it keeps the soil in an artificial state of friability, which takes the place of the superior texture we meet with on loamy soils. This is sometimes lengthened into a four-course rotation by growing barley after wheat. Barley is not a stiff-land crop, but the strong land can stand two corn crops very well, while the frequent fallowing combined with the use of farmyard manure tends to keep the soil friable enough to grow barley in a dry climate. The Norfolk rotation suits very well where clover is grown and bare fallow or mangolds make one of the shifts. On the London Clay in Essex, the Essex five-course shift is commonly practised: wheat, barley, roots or fallow, oats or wheat, beans or clover. The rule is that only the strong-land crops like wheat and beans can be depended upon, and at least half the fallow break is bare fallow.

Clay land of all kinds and under all climates is 'catchy' in its nature, *i.e.* must be caught just when it is fit. If taken when too wet, any work done will poach it and spoil it, while if taken when dry it sets like concrete, and there is extra power and tear and wear demanded. Loamy and sandy soils may be cultivated under all conditions, but clay must be taken just between the wet and the dry, to give satisfactory results. On the other hand, there is the compensation of having a soil with 'body' in it; that is, one full of the elements of fertility if you can get them out. The bare fallowing and perpetual cultivation enables one to effect this, and thus there are hundreds of cases of these strong lands that have been cropped for a generation without any manuring, and which still continue to yield good crops, and will go on doing so as long as they are thoroughly cultivated. [P. M'C.]

Continuous Corn Growing

The idea of perpetual corn cropping must have been attractive when wheat readily made 60*s.* or 80*s.* per qr. These prices were realized up to 1880, and 40*s.* was thought a poor price in 1884. Continuous corn growing has often been practised on the virgin soils of the New World,

but was always held to be disastrous in the end. Jethro Tull was the first Englishman who successfully carried out a system of continuous wheat growing in the same field, but not exactly upon the same land. Tull's system consisted in growing alternate strips of wheat, with bare-fallowed spaces, cultivated by hoeing and by a special implement. His wheat was sown in triple rows of 7 in. apart, but later he relinquished the middle row and sowed two rows 1 ft. or 14 in. apart. His land was ploughed into ridges with a deep trench between, and these ridges do not appear to have been wider than 3 ft. When the first crop of wheat was reaped he ploughed a furrow on either side of the trench, turning to the right, and thus 'gathered' to the open trench, filling it up. He then ploughed the stubble in two furrows, 'splitting' the old ridge, and leaving a trench in the middle of where the wheat grew the previous season. The system was to grow a double, triple, or quadruple row of wheat (all plans were tried) on a ridge separated by the trench already mentioned. The wheat therefore grew on a ridge and occupied 14 or more in., while the space between formed a trench. The next year, by following the system just described, the trench became the ridge and the ridge became the trench. Wheat was therefore grown alternately so far as the ridges were concerned, although the field grew wheat every year. It was, in fact, a system of alternate bare fallowing and wheat, and the fallow portion was ploughed, hoed, and forked during summer. The trenches between the growing wheat appear to have been filled by two furrows thrown toward each other, and the work was completed after harvest by throwing the furrows next the stubble also toward them. Ploughing and hoeing were the means employed, and the general result was as previously stated, wheat and fallow alternately. This was in a sense continuous wheat growing, and such was the luxuriance of the double, triple, or quadruple rows that as much wheat was grown per acre as if the entire field had been cropped. The Rev. S. Wilkins of Wix was a follower of Tull, and cultivated wheat for a great number of years upon a similar principle, which was described as the Lois Weedon system. Tull never manured his land, but relied entirely upon tillage, and taught that pulverization of the soil was all that was needed for securing good crops—a lesson which, although it may be true in the case of clays, is not reliable for light soils.

The leading authority in continuous corn growing during the 19th century was undoubtedly Sir John Lawes. His experiments were commenced in 1843, and are still continued under the Lawes Trust at Rothamsted. They have also been supplemented at Woburn Sands, Beds, for many years under the auspices of the Royal Agricultural Society. At Rothamsted, wheat has now been continuously grown on the same land for a period approaching seventy years, without exhibiting any failure as to yield in grain, bulk of straw, quality, or general healthiness. The results of the Rothamsted experiments on continuous wheat growing are supported by parallel series upon barley and oats, and the conclusion is that all the cereals may be grown continuously without deterioration. The practice at Rothamsted and at Woburn involves: (1) Continuous cropping; (2) the removal of the entire crop from the ground, both grain and straw; (3) unmanured plots; (4) continuous application of farmyard manure to certain plots; (5) continuous application of nitrates and ammonia salts; (6) continuous application of various mineral manures; (7) continuous application of nitrates, ammonia salts, and mineral manures (a complete manure); (8) alternate use of mineral manures and nitrogenous manures on alternate years; (9) the cessation of the application entirely at a fixed date, in order to find the duration of particular dressings; (10) comparison between continuous corn growing, and corn grown in rotation on neighbouring land. The Rothamsted results are recorded with great minuteness as to comparative yields of grain and straw, weights per bushel, money value of the samples, composition of the grain, periodic analysis of the soil, influence of the season, &c. The papers are illustrated by coloured diagrams and tables, and are very voluminous, and demand the full attention of the reader. The principal results obtained are, however, capable of being stated plainly and briefly, and are as follows:—

1. On the calcareous clay loams of Rothamsted the unmanured plot of wheat continues to produce 10 to 15 bus. of wheat per acre, and has shown surprisingly little inclination to discontinue its small but constant yield. It is also notable that this plot for a long series of years rivalled the average wheat yield of France, and still exceeds that of many of the States of America.

2. That an annual dressing of 14 tons per acre of farmyard manure has kept up an average yield of 33 bus. per acre, and that the same results are continued.

3. That the continuous application of nitrates and ammonia salts raises the yield considerably above the unmanured plots, but exhibits palpable signs of exhaustion. The average yield of these plots over thirty-two years was 20½ bus. per acre.

4. That mineral salts, applied yearly, produced only a small effect, and only raised the average produce 2 bus. above the permanently unmanured plots.

5. That a mixture of nitrogenous and mineral manures, compounded to represent a complete dressing, calculated to restore and add to the stock of plant food in the soil, maintained a yield of 32 to 36 bus. per acre for thirty-two years. The amount of the increase bore a striking ratio to the amounts of nitrogen applied, but the main point of interest lies in the fact that good crops of wheat can be grown year after year, if the mineral and nitrogenous constituents required by the plant are applied to the land.

6. In the case of a plot manured in alternate years with ammonia or nitric acid salts, and with mineral manures, the yields followed the same rule as when these two classes of fertilizer were applied to separate plots. When

mineral manures were used alone, the yield varied within considerable limits, but was only slightly better than the continuously unmanured plots, and much the same as when mineral manures were used alone. On each alternate year in which the ammonia or nitric acid salts were added, the yield rushed up to the same high level as the plot receiving the complete mineral and nitrogenous dressing.

7. With regard to the lasting nature or durability of the dressings employed, it is evident from what has been just stated that the effects of ammonia salts and nitrate of soda are very shortlived, and may be described as 'one crop' or 'one year' manures. The discontinuance of farmyard manure was followed by a very gradual diminution of yield. The conclusion upon this point is expressed as follows: 'When dung is applied continuously to land, the accumulation of unexhausted fertility becomes very large, and the removal by crops of the substances accumulated would extend over a long series of years'. Sir John Lawes expressed the opinion that one hundred years would not exhaust its effects! The difference between nitrogenous salts and farmyard manure lies in the fact that, in the case of dung, the nitrogenous matter is in organic combination and is slowly liberated as required, over a series of years, whereas, in ammonia salts and nitrate of soda it is liable to be washed out of the soil into the subsoil, and to reappear in the drainage water.

The above results all indicate the feasibility of continuous corn growing, and bear each other out in this respect.

The practical experience of Mr. Prout of Sawbridgeworth is worthy of notice in this connection. The present Mr. Prout's father bought the estate, and inaugurated a system of continuous corn growing forty years ago, which appears likely to go on indefinitely. Mr. Prout is quite satisfied with the results. He keeps no live stock, and sells all his straw, as well as grain, at an annual auction. The land is of strong character and well adapted for corn growing. It is also suitable for steam cultivation, and is laid out in large square fields with this end in view. The Committee of the Farmers' Club were invited to inspect the farms in 1905 and were much impressed by what they saw. The late Dr. Augustus Voelcker analysed the soils for the late Mr. Prout and advised the application of a moderate dressing of 3 to 4 cwt. of superphosphate and 1½ cwt. of nitrate of soda every year. He considered that there was no need of potash, as the soil is of clayey character, which is in itself almost a guarantee of potash. As to other mineral food ingredients, they existed in sufficient quantity already in the soil to indefinitely postpone exhaustion. It therefore appeared that the main ingredients which required to be restored were phosphates and nitrates, and there is no doubt that this conclusion would apply to all the clay soils of the country, unless in very exceptional cases. Lime might be deficient, it is true, but it can be added at intervals in accordance with usual practice. Dr. Voelcker's advice has been adhered to, and confirmed during recent years by Dr. John Augustus Voelcker, who succeeded his father as Chemist to the Royal Agricultural Society. This gentleman found no deterioration in the soil, but rather the reverse, after this long series of continuous corn crops. He contributed a paper to the Royal Agricultural Society's Journal in 1905, on 'Continuous Corn Growing in its Practical and Chemical Aspects', which is favourable to the system pursued by Mr. Prout. The writer of the present article also visited Sawbridgeworth just before harvest, and inspected the crops in company with the Committee of the Farmers' Club. Thorough drainage, as a preliminary, and steam cultivation, are the two cardinal points in the system. 'It is hardly an exaggeration to say that no sooner is a crop off a field than the steam plough is into it.' In earlier years Mr. Prout had his own steam tackle, but it was found cheaper to hire, and the usual cost is 13*s.* per acre. In the spring, horse-hoeing and hand-hoeing are both employed in order to eradicate weeds. After six or seven crops of corn have been taken in succession the land is sown with Trifolium, or more generally Red Clover, and it is then broken up. The crops are all sold, and the proceeds from the clover hay are satisfactory; but 'beyond this, the practice would, in the light of recent investigations . . . enrich the soil in nitrogen'. Besides this departure from uniform continuous corn growing, Mr. Prout bare-fallows his land when it requires to be cleaned. The precise course of cropping is guided by the condition of the land and the state of the markets. Clover is not sown oftener than once in eight years, and wheat, barley, oats, and beans are taken in the intervening years, either successively or continuously, according to circumstances. Roots form no part of the system. No bullocks or sheep are kept, and no farmyard manure is used for the general crops.

The manures employed are, for wheat, 4 cwt. of mineral superphosphate and 1½ cwt. of nitrate of soda; for barley, 3 cwt. of mineral superphosphate and 1½ cwt. of nitrate of soda. The superphosphate is applied in January for wheat, and at the time of sowing for barley; and the nitrate of soda is applied in one dose in the spring. No manure is applied to the clover, and no manure is used for wheat after clover, nor until the second corn crop is sown. The total cost for wheat cultivation is thus given by Dr. Voelcker, to whose valuable paper the writer is much indebted:—

	£	s.	d.
Steam ploughing, 10*s.*; coals, 2*s.*; man and horse, 1*s.*	0	13	0
Dragging and harrowing four times...	0	4	0
Drilling	0	2	6
Sowing artificial manures	0	1	6
Rolling	0	1	6
Hoeing	0	4	6
Harvesting and thatching	0	16	0
Threshing	0	8	0
Marketing	0	5	0
Seed	0	6	6
Artificial manures	1	5	0
Rents	1	5	0
Tithes, rates, and taxes	0	7	6
Interest on capital	0	8	0
Total cost per acre ...	6	8	0

Turning to the practical question of profit,

the average yield for the last twenty-five years has been 35 bus. of wheat, and the average price 31*s.* 9*d.* per qr. To this must be added an average yield of straw of 2 loads per acre disposed of at 25*s.* per load in stack. The total value of the produce has therefore been in wheat and wheat straw, £9, 8*s.* 10*d.*, leaving a profit of £3, 0*s.* 10*d.* per acre. Barley has proved less satisfactory, and the result is shown by the following figures, also based upon the last twenty-five years' average:—

	£	s.	d.
39 bus. of barley at 27*s.* per qr. ...	6	11	7
$1\frac{1}{2}$ loads of straw at 15*s.*	1	2	6
	7	14	1
Cost of cultivation as before... ...	6	8	0
Net profit per acre ...	1	6	1

In the case of oats the computation is as follows:—

	£	s.	d.
$6\frac{1}{4}$ qr. of oats at 17*s.*	5	10	6
$1\frac{3}{4}$ loads of straw at 20*s.*	1	15	0
	7	5	6
Cost of cultivation as before... ...	6	8	0
Net profit per acre ...	0	17	6

Analyses of the soil were made in 1865, 1877, and 1903, with satisfactory results. After twelve years of consecutive corn growing, the late Dr. Voelcker summed up his conclusions as follows: 'No fear whatever need be entertained that, under this system of cultivation and manuring, the land will be impoverished'. 'These words,' writes Dr. John Augustus Voelcker, 'written in 1880, have now (1905) received ample justification, for twenty-five years later we still find the son pursuing the system initiated under scientific advice by his father, and ready moreover, as has been shown, to maintain that the system is one that can be profitably carried out, despite the agricultural changes that have taken place in the meanwhile.' It is unnecessary to reproduce the analyses of the soils of the various fields in this connection, as the maintenance of the yield of the crops is the best answer to any doubts as to exhaustion. The figures given in the tabular statements as to composition of the soils, however, show clearly that in the interval between 1877 and 1903 there has been no decrease in fertilizing matter in the soil. Taking the average of three principal fields, there has been an increase in nitrogen, phosphoric acid, and potash to a remarkable degree. In lime, two of the fields show increases and one a diminution, but this cannot be regarded as of importance. Dr. Voelcker concludes his report in the following words: 'It may therefore be asserted from the chemical side, as well as the practical, that the system of continuous corn growing, as pursued by Mr. Prout, has brought about neither deterioration of the soil nor lessening of its productive power; and further, that it is a system which, under certain circumstances, may be profitably adopted at the present day'.

General Adoption of Continuous Corn Cropping.—Many visitors to Rothamsted, Woburn, and Sawbridgeworth have been much impressed with the results obtained, and have tried the system on a less rigid scale. Owing to recent legislation, farmers are now released from the shackles of prescribed courses of cropping, and especially from the provision that not more than two white-straw crops are to be taken in succession. Freedom of cropping and freedom of sale not unnaturally suggest a greater acreage of corn; and the following considerations may be of assistance in coming to a conclusion on the matter.

It is curious to reflect that when land is supposed to be exhausted it is asked to grow the most exhausting crop of the rotation, namely roots. This it is enabled to do with the assistance of manures, and the land subsequently benefits by the consumption of the roots on the land, together with supplemental foods. Still, until the roots are consumed the land must be rather severely exhausted in order to produce a good crop of turnips or swedes. Even more striking is the case of mangel-wurzel, which is cultivated in the same period of the rotation. This crop requires liberal treatment, and no wonder, for it is capable of producing in many circumstances 40 to 60 tons per acre. Strange to say this crop is removed from the land, and wheat generally follows it. Now the question arises why an intervening crop of wheat could not have been taken instead of the mangel, if the same manurial dressing had been applied? There seems to be no escape from the conclusion, and there is none. It may be that the mangel crop is more profitable, but the point is clearly established, that instead of wheat, mangel, wheat, the course might have been wheat, wheat, wheat.

The question of cleaning land is often raised, and we are told that root crops are necessary for this purpose. This is true, for even Mr. Prout is obliged to make an occasional fallow for cleaning the land. The writer has, however, found in his own experience that land may be kept clean under successive corn crops, if the ploughing is undertaken after harvest. Steam power is extremely useful for this purpose, and there is generally sufficient time in September and October to 'couch' and clean stubble so that it can be sown with wheat in October or November.

The question of soil-nitrogen is important in this connection. It is well known that the maximum amount of nitrates is present in soils before the autumn rains set in. In the case of all winter fallows which are awaiting root sowing, the land is exposed to the full effects of washing. One of the best effects of young seeds, rye, vetches, &c., sown in early autumn consists in their power to absorb and retain soil-nitrogen; and if this is accomplished by rye, winter barley, and winter oats, why not also with winter wheat? So far we will probably carry everyone with us in the argument—so long as the practice is to feed the green corn on the land. Still, the luxuriance of these fodder crops is a proof that the land is able to grow them, and the contention is that if these crops were liberally topdressed with superphosphate in winter, and nitrate of soda in spring, they would continue their growth and yield good grain crops.

Another objection to continuous corn growing

is the sacrifice of live stock. It does not, however, appear necessary to relinquish cattle and sheep; because it is not anticipated that root cultivation will be given up, but only moderated as to its extent. There are so many poor root crops grown, and the area is so often beyond the powers of the farmer to keep clean, that a smaller area of roots might easily produce as many tons as a larger area defectively cultivated. Under a modified system of continuous corn growing—that is, restricting it to fields suitable for the purpose, or carrying it out with breaks in its continuity on lighter soils—there seems to be no valid reason why it should not take its place as a part of ordinary farming. The writer's opinion is that sheep must be retained on light soils, but this has not prevented him from taking four or five corn crops in succession on the same light land.

Comparative Profits.—We next come to the question of profits. It must be allowed that after a crop of roots has been fed upon light land by sheep eating cake, corn, and hay, an oat crop of 80 bus. per acre is quite possible. This might be followed by 30 cwt. of hay and 40 bus. of wheat. If the root crop had been omitted these quantities would have probably been reduced to 40 bus. of oats, 1 ton of hay, and 26 bus. of wheat. The balance in favour of the root cultivation in this case would therefore stand as follows:—

	£	s.	d.
40 bus. of oats at 2*s.*	4	0	0
½ ton of hay at £3	1	10	0
14 bus. of wheat at 4*s.*	2	16	0
	8	6	0

The sheep ought to do much to reduce the debt on root cultivation and foods consumed, although we cannot venture to say to what extent; but the residual benefit is represented by £2, 15*s.* 4*d.* per acre per annum. Now the question which awaits solution is the cost of the nitrate of soda and superphosphate which would be necessary to keep up the above-named crops to their assumed level. If 3 cwt. of superphosphate and 1½ cwt. of nitrate of soda would be sufficient, the annual cost would be about £2 per acre.

It is, however, scarcely to be expected that such a moderate dressing could result in 80 bus. of oats, 1½ tons of hay, and 40 bus. of wheat, even if applied to each crop on this class of land.

In the Rothamsted experiments much heavier applications of nitrate of soda *plus* superphosphate, &c., are required to keep up a yield of 40 bus. of wheat per acre, and we are therefore led to conclude that three better crops would be produced after folding sheep with a liberal allowance of cake and hay than after dressings to each crop with 1½ cwt. of nitrate of soda and 3 cwt. of superphosphate. It must, however, be remembered that in a continuous system of corn growing carried on on the above principle there would be four crops of corn in four years, whereas in root cultivation there are only three profitable crops following a year of expenditure at an immediate loss. To place the case fairly before readers it would be necessary to insert a fourth corn crop and to add the value of the straw, as done by Mr. Prout. The Sawbridgeworth yields and values may be taken as fairly representing the value of the produce and the profits obtained on this particular class of land; but it is doubtful if they could be realized on the class of land best adapted for sheep-farming.

The problem is highly complicated, and impossible to reduce to figures that would be received by all as trustworthy.

The following factors of such a calculation are, however, worthy of attention:—

1. The substitution of four moderate corn crops instead of three ordinary, but better crops, after roots fed.

2. The net loss upon the roots, allotted to the three following crops in lieu of the cost of artificial dressings.

3. The proceeds of the sale of straw, in a system of farming in which live stock is excluded.

As to the net loss on the root crop, it is possible that in certain cases it might be converted into a balance on the right side.

If the expenses upon the roots are £5 per acre, and the crop supported 250 sheep per week, receiving 1 lb. of cake and 1 lb. of clover hay per day, they would consume on each acre—

	£	s.	d.
In roots	5	0	0
1750 lb. of cake at ⅞*d.* (£7 per ton)	5	9	4½
1750 lb. of hay at ¼*d.* (£2, 6*s.* 8*d.* per ton)	1	16	5½
Total against sheep ...	12	5	10 per ac.

If these sheep yielded 9*d.* per week gross return, then—

	£	s.	d.
250 sheep at 9*d.*	9	7	6
Showing a direct loss of ...	2	18	4 per ac.

Dividing this amount over the three crops, the annual charge for manuring would be 19*s.* 5⅓*d.* per acre. Sheep sometimes pay more than 9*d.* per week, and often less, but with abundance of swedes and 1 lb. per head of good cake, together with clover hay, 9*d.* is a moderate figure. If it could be realized, the verdict would be in favour of the usual four-course rotation. Teggs on ordinary keep are currently said to do well if they leave 20*s.* per head, and if this is calculated over a period of twenty-six weeks it represents 9¼*d.* per week. It does not therefore appear that there would be any great advantage in adopting continuous corn growing on sheep land.

The case of heavy land is entirely different. It is naturally adapted for corn, and is neither adapted for roots nor sheep, and it is upon this class of soil that the most successful experiments have been made upon consecutive corn growing. The system simplifies cultivation, for the actual tillages on corn are simpler than those for roots or fallow. If crops equivalent to those already mentioned are obtained, and the straw is sold, there seems good reason to believe that with the aid of a judicious system of manuring, the system might be widely adopted with success.

[J. WR.]

Co-operative Farming

Co-operation in farming is by no means a purely modern phenomenon, for in the primitive village community the communal cultivation of land and ownership of the more important implements was a general feature. But this system gave place to individualistic cultivation, and now the term co-operative farming refers only to societies deliberately organized for associated cultivation. The more general forms of agricultural co-operation, which have developed during the last generation, have not directly affected work on the soil itself. They have touched the preliminary processes by the provision of requisites, and the subsequent processes by such means as the organization of sales and the working up of dairy produce, but have left actual cultivation to the individual farmer. Yet it was the ideal of the earliest leaders of the co-operative movement in Britain to institute collective ownership and cultivation of the land by means of co-operative communities, and from the time of Robert Owen isolated experiments of this nature were made. A number of economists have thought that the principle of co-operation was particularly adapted to farming. The suggestion that associations of labourers might carry on production both in manufactures and in agriculture is made by Mill, while Fawcett looked to co-operation as a method of raising the position of the agricultural labourers, though they 'will have to advance towards it by many preliminary steps'. Turning from prediction to practice, we find singularly little to warrant these anticipations. The most successful of the agricultural communities organized on Owenite principles was the shortlived Ralahine experiment in County Clare (1831–3), where a farm of over 600 ac. was cultivated in common. It commenced with 52 members, 28 of whom were adult men, and the land, buildings, and stock were let to them by the owner for an annual payment in produce of the nominal value of £900, taking the average market prices for 1830–1 as the basis of computation. The hours of labour, wages, and arrangement of work were fixed by a committee, while the children were maintained at the cost of the society. Any surplus thereafter was shared among the adult members, and by November, 1833, the number of individuals in the community had increased to 81, 35 of whom were adult males, including a storekeeper, smith, and carpenter, as well as farm workers. The experiment broke down through the gambling propensities and consequent bankruptcy of Vandeleur, the owner, the land and improvements being seized on behalf of his creditors. Other Owenite communities in the United Kingdom, such as those in Cambridgeshire and Hampshire, were largely, though not purely, agricultural, the idea being to combine labour in the workshop with the cultivation of the land; but they proved complete failures. The ideal of a self-sustaining community had arisen not so much with a view to improving agricultural production or the lot of farm labourers as from the desire to get rid of the evils then resulting from the factory system. The same idea of land communities underlay the Union Shop movement (1828–32), many of the societies accumulating subscriptions and profits of stores for this purpose; and a few of the existing retail co-operative societies started with a similar object, though it soon fell into the background.

These separatist communities cannot be viewed as conclusive evidence respecting co-operative farming. We should look rather to experiments in common cultivation which have been organized in the interests of agricultural labourers without the questionable communistic features of the Owenite settlements. These have usually been instituted by philanthropic landowners, but without much success. The best known were the societies at Assington, Suffolk. The first commenced in 1829 when John Gurdon let a farm of about 100 ac. to 20 labourers with a view to ameliorating their lot, advancing also capital without any interest. This loan was repaid in a few years, and the success was so marked that the owner was induced in 1854 to let another farm to a second society of 34 members under similar conditions. Gurdon was able to report ten years later that there were 54 labourers farming about 350 ac., possessing all the stock and crops, and having repaid the money he had advanced. These labourers continued to hire themselves out to the farmers of the district, and spent the remainder of their time on the common farms, the profits of which were distributed in produce. Their acreage increased somewhat, and success continued until about 1876, when the series of bad harvests and the fall of prices proved too serious for them, despite a reduction of rent and loans of capital to the younger society from sympathizers. In 1892 it was reported that only one of the employees on the farm was a shareholder of the older society, so that it had ceased to be truly co-operative. Still less successful were the co-operative farms instituted by William Lawson near Carlisle, by Walter Morrison in Herefordshire, and by Bolton King at Radbourne and Ufton. In Morrison's experiment 148 ac., half arable and half grass, were let in 1873 to a society of labourers, three of whom gave their whole time to the farm. Its failure, after six years' existence, was attributed to the incapacity of labourers to manage a farm. More interesting were the attempts of King. The Radbourne Society acquired in 1883 a farm of about 350 ac., along with stock and implements hired from the landlord. Of the net profits, it was provided that 20 per cent should go to a reserve fund, 40 per cent towards purchase of the stock and implements, and the remainder to the manager and members in proportion to their wages. Besides the manager, there were 12 able-bodied men, 2 youths, and 2 boys employed on this farm, and in the first year there was a small profit after paying interest on capital, though subsequently losses were the rule. Meanwhile, in 1885, King rented the Ufton farm of 407 ac. to be worked on the same principles under the same manager, but this yielded a loss from the outset. Notwithstanding a change of manager the writing off of losses by King, the reduction

of workers on each farm to 9, including the manager, some of whom worked short time during the winter, losses continued. In 1890, when the societies were dissolved, King said: 'So far as conclusions can be drawn from these two experiments, I think the evidence is against the likelihood of co-operative farming paying at the present day'. The chief causes of failure were thus expressed by him: '(1) The heavy charges on the scheme. Before any profit can be declared, interest and wages of superintendence amounting together to 7 per cent, must be allowed for. A farmer working on his own capital would count both these as profit. (2) I am obliged to conclude that the fact that those working on the farm have no capital invested is a deterrent to the keen interest which co-operation might be expected to inspire. The work has been good and careful, but there has not been that excess of interest and enterprise which I had hoped for.'

The most important separate society on co-operative lines in Scotland was the Scottish Farming Association, which had the support of the consumers' associations both in the supply of capital and as an outlet for their produce. Their first venture was a dairy farm at Torrance of Campsie in 1888, but this was abandoned in 1892, though meanwhile other farms were procured. They paid bonuses to the workers and to the consumers on the amount of wages and purchases; but despite the assured demand of the co-operative stores and dairies of Glasgow for their produce, the experiment was brought to an end in 1898. On the other hand, a co-operative cow club organized by pitmen in Northumberland has had a prosperous career, and club farming in other matters has met with some success in a few localities. Attempts to raise agricultural labourers by means of co-operative farming have seldom originated among themselves, and have generally been disappointing even when ungrudging aid has been given by landowners and other sympathizers. In the latest list of societies included in the Labour Copartnership Association, seventeen are mentioned under the head of 'Agricultural', but with scarcely an exception these must be excluded from the term co-operative, being merely societies of farmers who give some part of the profits to their employees without any share in the management. Some have considered such profit sharing as the transition stage towards true co-operation; others advocate it for itself because it 'blesseth him that gives and him that takes' by increasing the exertions of labourers, and thus creating an additional profit. But these views have as yet commended themselves to few agriculturists.

The term co-operative farming is often applied to the efforts of the distributive stores and wholesales to institute productive departments on the land. The distinctive feature of these farms is that they are organized in the interest of consumers, not of the producers, even though some of them incidentally give some share of profits to the labourers. The report of the Central Co-operative Board for 1907 mentions 70 such farms and market gardens, with 9281 ac. It might be thought that such farming would be very successful because of the direct outlet for their produce through the stores, but while this is true of some, others are markedly unsuccessful. The profits in 1907 were £5844, and the losses £4604. In 1891 the Scottish Wholesale Society took over the Carbrook Mains farm, but lost heavily and abandoned it in 1901, taking another near Lanark, which appears not to have proved conspicuously successful. Probably the advantage of an assured outlet for produce is more than counterbalanced by the fact that cultivation by hired labour is much less efficient than direct supervision by a farmer personally interested in obtaining the largest amount of produce from the land, and giving his time and labour, along with that of his family, in a way which seems incompatible with anything but individual farming. So far, it appears that cultivation in the interests either of associated labourers or of associated consumers is economically inferior to cultivation by individuals who control their own farms, have every inducement to get the best results, and to give unqualified care to the peculiarities of each field. Recognizing this, agricultural co-operation in other countries has left the cultivators in complete possession of their individual farms, and achieved its success by facilitating purchase, marketing, and the working up of products after they have left the farm. Consumers' co-operation is apt to conflict with this at some points, when the wholesales own creameries in Ireland, and the distributive stores annex farms. In the delimitation of functions suggested between the Co-operative Union and the agricultural organization societies this overlapping might be prevented by handing over the creameries to societies of farmers to be conducted on the principles advocated by the latter bodies, and by the stores encouraging separate farmers' associations instead of attempting to do their own farming.

[S. H. T.]

Dairy Farming

(*a*) *The Production and Sale of Milk.*—It may appear strange, but we believe it to be entirely correct, to differentiate in farming for milk, for butter, or for cheese production, both as regards the cattle and the food. The milk producer must reach a standard, although a very low one, and yet his milk should be well above it, because the normal milk of a herd always exceeds 3 per cent of butter fat. This once achieved, the object of the farmer is to produce as large a quantity as possible; hence the importance of selecting cows of deep milking breeds, and of supplying them with food which is calculated to increase their yield. Of the various British breeds none are superior, possibly none are equal for this purpose, to the dairy Shorthorn and the Ayrshire, the former standing first, for the reason that her calves are of greater value, and her carcass suitable for butcher's meat when her milking days are done, those days being completed at a somewhat early age, owing to the advisability of slaughter before age makes her flesh too tough. No money is better spent in stock than in the selection of the best. A few

pounds more than the average price paid for a first-class cow is more than repaid in her first year. She should possess an udder which is both long and broad, and wide between the buttocks, the teats placed well apart; while her yield for some time after calving should reach 5 gal. daily, and at least an average of 650 gal. a year. This quantity may be easily exceeded by constant selection and the use of a daily record, kept by bodies of farmers who combine on the Scottish plan. There are cows in almost every herd which fail to pay their way; these should be sold or fattened for the butcher, and their places taken by selected stock. If this practice is continued systematically the average yield of milk will increase with every year, until a point is reached when further increase may be difficult. The best milkers—especially those which are best in form, character, and quality of flesh, which terms imply docility and mellowness of skin, with breadth across the hips, well-sprung ribs, fine fore quarters and lengthy heads, the muzzle being powerful—should be retained for breeding purposes, while bulls should be employed which are the scions of deep milkers while possessing the character and type of a good dairy Shorthorn. As it becomes essential to dispose of cows, they should be sold near calving, or fed while still milking until the yield has so far diminished that they no longer pay their way as milkers, and can be sold to the butcher.

A herd of dairy cattle kept for the sale of milk should be well fed upon rations which are carefully selected, and in large part grown upon the farm. The system of cropping depends upon the soil and climate. In the west of Great Britain, and in almost all parts of Ireland, where the rainfall is greater than in the east and south, dairy farms are chiefly under grass, but it is unwise to depend on grass altogether; oat straw, both for litter and food, is needed in the winter, together with roots and cabbage, while in the hottest part of summer and early autumn the grass is often parched and poor, and the milk supply falls off. It is for this reason that even upon a grass farm a strict but simple rotation should be followed, oats, roots, and forage crops being produced in succession. First of all, the grass land should be maintained in the highest possible condition, not depending entirely upon the cows for its manure, in spite of the fact that they may be well fed upon cake and meal. It is surprising what is possible in these later days in the production of grass. Phosphates, perhaps, are the most important form of manure, because it is next to impossible to grow large quantities of clover and trefoil without them. Where these plants grow with freedom the manure of the stock is enriched with nitrogen because the plants are rich in that element; thus phosphates indirectly pave the way for the manuring of the land with dung which is richer in nitrogen than would otherwise be the case. If the land is rich in lime, super- or acid phosphate may be supplied; if, on the other hand, it is poor in lime, basic slag is better, or superphosphate followed by a dressing of lime itself, the lime being supplied in sufficient quantity to neutralize the acid or superphosphate; or basic phosphate may be given. We have found these three manures cause the grasses to respond in a generous way; and although the cost is higher, we have also found that the liberal employment of guano, rich in both phosphates and nitrogen, has been followed by a rich crop of white clover.

With regard to the production of forage crops for summer use, much depends upon the district; lucerne and maize grow with great freedom and profit to farmers in the southern half of England, but neither is suitable to the north and Scotland. The remark applies in an almost equal measure to trifolium and sainfoin, both of which, like lucerne and vetches, which are also strongly recommended, belong to the Leguminosæ, so that where these crops are supplied to cows they should be accompanied by food rich in starchy matter, such as maize or rice meal. On the other hand, where maize is grown for consumption in its green form, or rye, one of the earliest fodder plants, its use may be accompanied by cotton-seed meal or cake, or bean meal, both of which are rich in nitrogen, in which both fodder plants are poor. It may be worth remarking that in the employment of cotton cake it is more economical to use the best, in spite of the difference in the price. The decorticated or best cake contains some 61 per cent of digestible feeding matter, whereas the common cake, which contains husk in large quantities, contains only 38 per cent, this being altogether out of proportion to the price. Rape cake is food of considerable value, owing to its richness in albuminoids, but it is difficult to induce dairy cows to eat it; hence, the demand being small, the price is small as well. On many farms the employment of cake or meal in summer is uncommon; but on the best dairy farm with which we are acquainted we have seen the cattle feeding in pastures so luxuriant that the herbage reached above their knees, and yet they were receiving some 4 lb. of ground oats and bran daily. It is important that where forage grasses are supplied they should be gradually introduced, and never given to the cows too young or when full of sap; they are better cut a day before they are required, and given slightly wilted, for, as in the case of cows which find their way into a forage field and eat heartily, freshly cut vetches, lucerne, trifolium, and other green crops are liable to cause hoven, from which a valuable cow may die.

Whether milk is produced upon a grass or an arable farm, a ration of chopped food should be prepared. On the grass farm more hay would be supplied, both in the chop and in the rack, but on the arable farm very little hay is given, possibly only a small quantity for the night. The basis of a chopped ration should consist of oaten straw and roots, with mangels, swedes, or turnips; but mangels are much better after Christmas, when they are riper. Swedes, whenever they are given to the cows, should have the crown removed before pulping, for all roots should be pulped, a fact which equally applies to kohlrabi, which is of much greater value than is generally supposed. Cabbages which

grow with large white hearts are almost as useful as mangels, and may be employed upon a butter farm with advantage. The chopped straw and roots mixed with sweet brewers' grains and meal or crushed cake will form an excellent ration. The farmer has many concentrated foods to select from, and he usually chooses them in accordance with their price. We may take an example and compare oats with maize, both of which should be crushed. Taking maize to weigh 60 lb. to the bushel and to contain 74 per cent of digestible feeding matter, we get, practically speaking, 45 lb. of food to the bushel, which at 24*s.* per qr. would cost 3*s.* If we take oats at 40 lb. to the bushel and estimate the feeding matter they contain at 57 per cent, we get only $22\frac{3}{4}$ lb. of digestible feeding matter, which at 20*s.* per qr. would cost 2*s.* 6*d.* Thus the oats cost twice as much as maize as actual food. We must, however, point out that the oats are better balanced, that the ratio of albuminoids to carbohydrates and fat is 6·1, whereas in the case of maize it is 8·6, so that something should be allowed for the fact that they are a better food. On a dairy farm, whether it is principally under grass or not, if hay is employed it should be of the very best; there is no economy in selling the choicest hay and reserving the inferior for the stock. The best hay is that which is cut when the stems are full of sap and the seed in the milky stage; but it must be well harvested, for if left too late, until the stems are tough and wiry and the seed has formed and shed, the hay is very little better than straw. It should be added that a ration which is prepared as we have suggested should be left until it heats, and given to the cattle in a warm condition. However cold the weather, fermentation will follow mixing, and the food will be relished, owing not only to the fact that it is warmer, but that a flavour has developed, which apparently satisfies the palate of the cows.

It has been urged more than once that dairy cows should receive linseed cake, owing to the importance of oil in the ration and its value in adding to the fat percentage of the milk; but the result of various experiments has shown that milk cannot be improved in its fat percentage by the addition of the fat of food. Food has indeed been supplied to cows from which every particle of fat or oil has been extracted, without making any difference in the quality of the milk. Cows in poor condition may be improved by feeding them on linseed cake. By steeping flax seed or linseed in water and producing an emulsion by the introduction of a jet of steam, a highly nutritious mixture may be prepared, which should subsequently be poured over the ration in the manger.

A herd which is carefully collected and well managed should give a return—including the value of the calf—of from £20 to £22 per cow per annum; but from this it would be necessary to deduct the cost of the carriage of the milk, and the cost and maintenance of the necessary plant—the churns in which the milk is carried, refrigeration, and other minor items which come essentially into the milk account. In those districts in which cheese is largely made, it is a common plan for the farmer to produce good cheese in summer and sell his milk in winter at winter prices. Every dairy farmer should ally himself to the association which represents the dairy interest of his county, for in this way higher prices have been obtained for milk, which produced under modern conditions is worth more than it has realized in the past. As it is important that cleanliness should be observed in everything, time and money are involved; and it may be added that where manure—to take one example—finds its way into the milk, only about one-eighth can be subsequently removed. This fact was ascertained by repeated experiments by Dr. Thomas, the analyst for Chester. On the other hand, milk contains other objectionable materials, which when submitted to separation form a sediment or slime. Ten years ago the quantity found in large numbers of samples of milk sent into Manchester was estimated by Professor Delépine to reach 106 lb. per day; two years ago that quantity had been reduced to 79 lb. One portion of this sediment is quite harmless, but the other portion is not. Before 1900 the objectionable sediment amounted to 66 lb. per day, but it has been reduced to 39 lb., while the percentage of clean milk now reaches 60 per cent of the total instead of 40 per cent, which was the case eight years ago. In view of the publication of such facts as these, and of the action of the Government and of the local authorities, dairymen are becoming more exacting, and consequently the dairy farmer will be compelled to adopt more drastic measures, which will naturally result in his requiring a better price. Instead of 1*s.* 2*d.* per barn gal. of 17 pt. in the summer and 1*s.* 6*d.* in winter, he can now obtain an average of at least eighteenpence per gal. Where a farmer sells his milk he is usually obliged to make a contract, but he should take the greatest care to read it through before he signs it.

(*b*) *Butter Production.*—Our remarks on this subject are based on personal experience, but chiefly upon the practice of the most successful makers with whom we have come in contact in the course of the past thirty years. Among these are Dr. Watney, the owner of the unrivalled herd of buttermaking Jerseys, and M. César Vautier, a French gold medallist, and one among many Norman makers of distinction whom we have visited in the past. To make butter of the finest possible quality is one thing, and that difficult, but to make such butter in almost unequalled quantities is another. Such success is only possible to those who persevere for years, exercising skill in the selection of their stock, in feeding and good management, and in the manufacture of the butter. The cattle owned by Dr. Watney are not only selected cows, but they are large, and strong, and milkers of the highest order known in the British Islands. Those owned by César Vautier are selected Norman cows, large, and deep rich milkers, not unlike the choicest dairy Shorthorns which obtain prizes at the National Dairy Show at Islington. It should not be forgotten that with our great English

dairy breed, the unpedigreed Shorthorn, it is possible to obtain both quantity and quality of milk. On one occasion we selected from a large number of Shorthorn cows a small herd of exceptional quality, having previously seen them milked, with the result that during the short period they were under experiment they produced butter at the rate of 5 per cent of the milk yield, or 1 lb. to every 2 gal. of milk.

To attempt to produce butter at a profit from an average herd, and under what we may term ordinary conditions, is useless. There are far too many farmers who market their butter at from 7*d.* to 10*d.* per lb., and who receive, in consequence of the low price obtained and the small production of their stock, a return of from 3*d.* to 4*d.* per gal. for their milk. We take, however, an example of a more than average return, and compare it not only with what is possible, but with what is actually obtained. Thus, at a price of 1*s.* per lb. of butter, to which we add the value of the skim milk, the buttermilk, and the calf, a cow yielding 600 gal. of milk per annum would produce 218 lb. of butter, on the assumption that each pound is extracted from 2¾ gal. of milk, which is about the average return. The account would stand as follows:—

	£	*s.*	*d.*
218 lb. of butter at 1*s.*	10	18	0
Calf	1	10	0
550 gal. of offal milk at 1½*d.* ...	3	8	9
Total	15	16	9

We have placed the price at 1*s.* per lb., although it is far beyond the average, a remark which equally applies to the yield of milk, which in this country we may with confidence place at 450 gal. at the outside. To succeed in producing butter as a leading article on the farm it is essential to make it a special object of attention. The cows must be the selected individuals of a selected breed, whether that breed be the Jersey, the Guernsey, or the Devon. It is true that, as we have suggested, dairy Shorthorn stock can be obtained which will produce large quantities of butter, but in no case do we remember an instance in which the quality of this butter has equalled that produced by the three breeds which have been suggested. The object of the buttermaker is to obtain both quantity and quality, and the object is secured not only by selected stock and skilful management, but by milk which produces butter of rich colour, waxiness of texture, nutty flavour, and a low percentage of water. It is recognized in practice that butter made from milk of cows in which the fat globules are large is waxier and richer both in colour and flavour than the butter made from milk in which the globules are small; for instance, it was shown by Dr. Peter Collier that the ratio size of the fat globules in the milk of the Guernseys was 133, in the Jerseys 121, in the Devons 111, in the Shorthorns 103, and in Ayrshires 100. This fact may be practically demonstrated by examining a drop of milk from each of these breeds of cattle under the microscope, and noting the relative size of the globules. Again, when milk is set for cream in the oldfashioned way in shallow pans, the largest globules rise to the surface first; hence the reason why the best French makers, who still raise their cream in pans by gravitation, although these pans are deep, make their finest butter from the first cream which rises, and which they call the *fleurette*.

Now let us suppose that we take a herd of well-selected cows intended for making butter, and assume as before that their average yield is 600 gal., and that every pound of butter they produce is extracted from 2 gal. of milk. The result would be a yield of 300 lb., which is an excellent average, although very much smaller than is obtained by the owners of the best dairy herds. Dr. Watney, for example, has obtained an average yield of 450 lb. of butter from a herd of some thirty cows, for which he has obtained no less than 1*s.* 6*d.* per lb., and it need hardly be added that the quality is of the finest. This particular herd is kept solely for the production of milk and butter, and the most careful accounts are kept, while from year to year a balance sheet is prepared by a London expert. It is important to remark that the cows are not what are termed 'dual purpose' cattle, although we apply the term in a somewhat unusual way —they are not intended to obtain prizes for their appearance on inspection when they are exhibited at shows, for they are larger, more substantial, and more fleshy than the Jersey which is bred for exhibition. We return, however, to our figures, and suggest that butter of the quality obtainable from cows of first-rate butter breeds should return an average price of 1*s.* 2*d.* per lb., though this sum is very often exceeded. The gross returns would be as follows:—

	£	*s.*	*d.*
300 lb. of butter at 1*s.* 2*d.*	17	10	0
Calf	1	10	0
Offal milk, 550 gal. at 1¾*d.*	4	0	3
Total	23	0	3

The price placed against the calf in each case is nominal, and it must be so for the simple reason that a good Shorthorn calf, especially a heifer or a bull which has a pedigree, is worth something more, while a heifer calf of either of the butter breeds might realize 60*s.* or even more. On the other hand, bull calves of these breeds, unless in exceptional cases, realize very little.

Next to the breed selected comes the feeding and management. Contrary to all preconceived ideas, it is practically certain that both the Jerseys and the Guernseys should be more fleshy than is commonly the case, grazing in rich pastures in summer, during which period they receive a small ration of crushed oats or bran, to the exclusion of oilcakes, maize meal, bean meal, or brewers' grains, all of which are risky foods where the flavour of the butter is in question; whi' in autumn they may receive certain well-selected forage crops, including the white hearts of cabbage, parsnips, carrots, small quantities of lucerne, vetches or clover, with good results. In winter they should be allowed to graze as much as possible, for which reason some grass should be specially reserved for their benefit.

The ration in the manger, which should be prepared with skill, may include the foods al-

ready mentioned, with the earliest-cut and sweetest hay, which should be specially reserved as the most important portion of their ration. Brewers' grains, turnips, swedes, ensilage, inferior hay, and all materials which may possibly impart a flavour to the butter should be carefully excluded. Every cow should be daily groomed and stalled on a bed which will prevent the possibility of the staining of her haunches or her udder with dirt of any kind. There should be perfect ventilation, the purest water to be obtained, while the udders should be washed before every milking; and we need hardly mention that in every particular the process from milking to marketing the butter should be scrupulously clean. There should be no potting of the butter, while in the hottest weather it should be firm; soft, tainted, or highly salted butter may cause the loss of many customers to the dairyman, whereas his object should be to gain and retain them, especially when they pay a liberal price. The milk should be tested as often as possible, and every cow which yields less than 4½ per cent of fat, unless she has redeeming points, should be replaced by a better one. It must be remembered that in almost all our buttermaking competitions a large proportion of the cows exceed 2 lb. of butter in the day, while in occasional instances a Jersey or a Guernsey has produced nearly 3½ lb.

The sale of butter when combined with the sale of milk is not satisfactory. Buyers of milk are unwilling to pay a higher price simply because of the superiority of the milk in fat; yet there are occasional instances when the distance from town or rail compels the farmer to make butter from time to time, as in summer, when the price of milk is low, or in winter, because it pays him better. We would, however, advise those who are attempting to maintain a double-purpose herd to keep a herd for selling milk or select one suitable for making butter as we have suggested, and we believe that if the business is well planned and the practice what it should be, buttermaking will pay the better of the two.

(c) *The Production of Cheese.*—The richer the milk in solid matter the larger the quantity of cheese produced. It has been customary in the past to suggest that a given breed of cattle or a given type of cow is suitable for cheesemaking purposes, although the quantity of solids in the milk produced is comparatively low. The Ayrshire cow, for example, is, for her size, a deep milker, and the milk she produces is excellent, but it is not sufficiently rich in solids to produce a large percentage of cheese. The remark equally applies to the various types of cattle which are used in England, whether for the production of Cheddar in Somerset and the adjoining counties, or in Cheshire, Lancashire, Yorks, Leicester, and Derby, where cheese of other types is produced. We do not, however, lose sight of this fact, that the cheesemaker is, as a rule, a milk seller in the winter season, and that, combining the two practices, the manufacture of cheese in the summer when milk is cheap, and the sale of milk in the winter when the price is higher, he makes his business pay. Again, however, it may be pointed out that a large proportion of the cheesemaking farmers of the country retain cattle which are not rich milkers; they act upon the principle that in selling milk it is quite unnecessary to supply milk with a higher percentage of butter fat than is required by the standard, viz. 3 per cent, and they prefer in consequence cattle which are deep milkers, without paying any special regard to the richness of the milk, so long as it is sufficient for their purpose, *i.e.* for milk selling.

Let us refer to some facts which bear upon this case. At the great dairy tests at Chicago, seventy-five cows were tested for fifteen days; they included twenty-five of each of the three important breeds — Jerseys, Guernseys, and Shorthorns. The quantity of milk required to make 1 lb. of cheese in the case of the Jersey was 8·11 lb.; 9·6 lb. in the case of the Guernsey, and 11·3 lb. in the case of the Shorthorn. The result was that during the fifteen days the Jerseys produced 1451 lb. of cheese, the Guernseys 1130 lb., and the Shorthorns 1077 lb., while the whey was much larger in quantity in the case of the Jerseys than in the Shorthorns. At the experiments at the station of Geneva in New York State, which were extended over a considerable time, large volumes of milk being manipulated from day to day, the average quantity of fat in the milk was 4·56 per cent, while the total solids reached 14 per cent. What was the result? The quantity of cheese varied from 9·75 lb. to 14·2 lb. per 100 lb. of milk, and averaged no less than 12·35 lb. This works out to the somewhat extraordinary figure of 8·09 lb. of milk per pound of cheese. It was found, after careful examination, that the quantity of water retained in the cheese was in proportion to the richness of the milk, although there are certain differences which occur where the process of manufacture is varied; for instance, the variation was between 3·2 lb. and 6·39 lb. per 100 lb. of milk, the average being 4·7 lb. Again, it was found that the quantity of fat per lb. of casein in the milk varied in accordance with the richness of the milk. When the milk was richest it contained 1·56 lb. of fat to every pound of casein, but at the experiments in the west of England in 1892 the quantity of fat per pound of milk was 1·25 lb., and in the following year 1·20 lb. The remark applies equally to the cheese; the larger the quantity of casein the larger the quantity of fat. Again, it appears that there is a greater loss of fat in the manufacture of cheese when the milk is poor than when it is rich in total solids. In the richer milk there is a larger proportion of solids recovered in the cheese than when the milk is poor. Taking the work conducted at forty-eight factories, it was found that of the total solids of the milk employed, 50 per cent was recovered in making cheese. The fat recovered reached 91 per cent, and the casein and albumin 75·7 per cent. The solids lost consisted chiefly of sugar, the chief constituent of the whey, which is mostly employed in feeding pigs.

The relationship of fat to the whey of cheese produced is shown very clearly when the milk is divided into groups in accordance with its quality; for example, when the fat percentage

varied from 3 to $3\frac{1}{2}$ per cent, the fat lost to the cheese but present in the whey reached 9·55 per cent, while the weight of cheese produced per 100 lb. of milk was only 9·14 lb. So the figures vary consistently until we reach the milk of the highest quality—5 to 5·5 per cent. Here the proportion of the fat lost in the whey was only 6 per cent, while the quantity of cheese produced per 100 lb. of milk was 13·6 lb. It will be at once noticed by the cheesemaker and those who are connected with the industry in other ways that the man who makes cheese on the farm is wise to form his herd not only of deep, but of rich milkers — the richest he can find — and that he should spare no pains to exclude inferior cattle and to replace them by the best. On the other hand, it shows that farmers who contribute to a cheese factory should make a point of obtaining payment in accordance with the quantity of cheese produced from the milk they send. If the price paid per gallon is for all qualities, the producer of poor milk obtains the same price per gallon as the producer of the richest milk. If we take as an example what has actually occurred, it may be pointed out that a quantity of milk containing 3 per cent of fat returned to the farmer 5*s.* 5*d.*, while for the same quantity of milk of another farmer sent to the same factory and containing 5 per cent of fat, the amount received was precisely the same, although this milk had produced $13\frac{1}{3}$ lb. of cheese against $8\frac{1}{4}$ lb. produced by the poor milk to which we have referred. On the basis of quality, the farmer sending the poor milk would have received 4*s.* $1\frac{1}{2}$*d.* as against 6*s.* $8\frac{1}{2}$*d.* due to the farmer sending the rich milk. It should be remembered that in making cheese milk which is rich in fat, as it should be, is also richer in casein than milk of an average quality, and that its richness is accompanied by a greater power of retaining water and mineral matter. There are, therefore, two sources which contribute to a larger weight of cheese.

There can scarcely be a doubt that the wisest plan of the cheesemaking farmer is to select his cattle from among the larger breeds, taking care to ensure both deep and rich milking; to do otherwise would immensely reduce the weight of his production. Although it is contrary to the practice of dairymen, a farmer with a herd of rich milkers should make a point of obtaining payment in accordance with the quality he produces. The dairyman is not as a rule in a position to dispense with a farmer who supplies milk of high quality upon which he can always depend. So far as feeding is concerned, it is not essential to adopt the methods which are followed by the farmer who produces butter; the cows may receive a greater variety of forage crops in autumn, with cotton cake and the various meals and other concentrated foods which are used in the winter season by the farmer who produces milk for sale. Owing to the fact that cheese is a summer product, the cows are chiefly fed on grass; but they may always, and with advantage, be supplied with a small quantity of the best cotton cake, crushed oats, bean meal, bran, rice meal, malt culms, or maize meal, in order that they may not only maintain their yield of milk, but the flesh upon their carcasses. [J. Lo.]

English *v.* Scotch Farming—A Comparison

No agriculturist going from one country into the other can help being struck by the very great differences existing in the farming methods employed in the two countries. The change from one to the other takes place more particularly in the counties of Northumberland, Cumberland, and Durham; Yorkshire, even its northern parts, being quite English, and Berwickshire being quite Scotch. The different practices are, as a rule, well founded on the bedrock of experience, but there are some on both sides that it is difficult to understand.

One of the most striking differences is in the depth of the ploughing. The English farmer believes, as a rule, in rather shallow ploughing, whereas the Scotchman is rather keener on depth. So far, the writer has been unable to find any underlying reason for either practice, and is inclined to think the English farmer might plough his heavy lands deeper, and the Scotch farmer save something in horse flesh by ploughing his light land much shallower without detriment to his crops. The Scotchman is always very much amused to see the three horses one behind the other at plough, but the Englishman is quite as keen in most cases to plough with a pair, or even with three horses abreast in a double-furrowed plough, when he thinks he can do it without detriment to his land; and it is possible that some of the carse lands in Scotland would lie drier in the spring if they were less puddled by the horses' feet.

The general system of farming in the arable districts is practically the same in both countries. In the eastern parts the four-course rotation of turnips, barley, clover seeds, and wheat or oats is usually followed, sheep being fattened on the turnips, and cattle in the houses or yards. In the western parts of both countries the four-course system is less strictly adhered to, dairying and cattle raising are common, and temporary pastures are more frequently used. Certain districts are largely devoted to potatoes and market gardening, though potatoes are also grown in place of turnips in the ordinary rotation. For many years the Lothian farmer stood pre-eminent as a potato grower, but he is now being rapidly approached by his English neighbours, and it is probable he has been overtaken in certain districts. There is no doubt, however, that in most cases it is the Scotch farmer who has taught the Englishman how to grow potatoes, and that most of the up-to-date machinery and such practices as the boxing of sets have always travelled south. The quantity of artificial manures used upon potatoes in Scotland is usually very much greater than that commonly applied in England, dressings often running as high as 15 cwt. or 18 cwt. per acre. While speaking about potatoes it is well worth mentioning that early potatoes are principally grown in Ayrshire and Bedfordshire, and that in spite of the difference in latitude both are ready for the market practically at the same time. In the use of artificial manures the Scotch far-

mer has always been far ahead of the southerner. It is true there are exceptions on both sides: the Norfolk farmers have used phosphatic dressings for close on a hundred years, and it is probable there are farmers in the remote districts of the north who have still no faith in artificials. Generally, however, the northerner understands his manures, he knows what suits his soil, he can calculate out his mixtures, and he uses nothing at haphazard. All this is equally true of a certain number of English farmers, but the proportion they bear to the class of men who ask you if kainit or nitrate of soda will be the best topdressing for wheat is greater in England than in Scotland. If one criticised the Scotch farmer at all with regard to the use of artificial manures, it would be to suggest that the large dressings of superphosphate, dissolved bones, bone meal, and other substances he uses for his turnips could be reduced with equally satisfactory results.

Turnips, as distinguished from swedes, are much more commonly grown in the north than in England, and they are invariably grown in drills or ridges. In England the common turnips are nearly always sown on the flat, the swedes, which form the larger part of the root crop, being mostly but not always sown on ridges. The date of sowing varies from early in May in the north to the end of June in the south for swedes, and for turnips from May in Scotland to the end of July in England. Two things about the cultivation of turnips in Scotland always strike the English farmer. The first is the 'little ploughing', or ploughing between the rows of growing turnips, a thing never practised in England; and the second is the enormous gangs of women employed in hoeing, and the slowness with which they seem to work.

Another crop grown on drills or ridges in Scotland is the horse bean. The plan is an excellent one, enabling the crop to be kept thoroughly clean, but it is seldom practised in England, though it may be seen occasionally as far south as Flintshire.

The greatest possible divergence of opinion and practice prevails between English and Scotch farmers on the subject of haymaking. The Scotch farmer regards hay that has heated in the stack as spoilt, while the Englishman likes his hay to heat a little, and considers that much of the northern hay is fit only for litter, being often mouldy and lacking in scent. Each farmer is strongly of opinion that his own particular class of hay is the better, and it would be useless to attempt to fight out the battle here. Strongly heated hay is certainly injured, but hay that has been exposed to the weather so long as to give it a musty flavour is just as certainly spoilt. The hay in the north is almost entirely clover and rye grass; in the south, permanent grass forms the larger bulk; but even taking the clover and rye-grass mixtures in both countries, the methods of proceeding to turn them into hay are quite different. In England the crop, having been cut by the machine, is left until it is dry on the top, one or two days, the swathes are then turned and allowed to dry right through, usually another one or two days. If no rain falls, the hay is put into cocks of convenient size for lifting on to the cart in one forkful, and it is carried to the stack immediately. In Scotland the hay is got together, often before it is actually fit for carrying, into coils, and afterwards into 'tramps' or ricks, each containing from 7 cwt. to 12 cwt. of hay. These ricks are then raked down, have two weighted hay ropes thrown over them to keep the wind from destroying them, and are left in the field often for three or four weeks till it is convenient to carry them to the large stack (called 'sow' in Scotland). To the ordinary observer there seems no reason, climatic or otherwise, why in dry weather the hay should not be carried to the stack as promptly as in England, and on the other hand the Scotch method could often be adopted with advantage farther south when the weather was showery and unfavourable.

One very striking feature of Scotch farming is the absence of permanent pastures as they exist in England. There are, of course, permanent grass lands, but beyond a field or two adjoining a house they are usually lands that could not possibly be cultivated—meadows liable to floods, hillsides, moors, and such like; but one seldom sees stretches of permanent grass on some of the very best land in the country, as one sees in England. The country is undoubtedly the gainer by the land being kept under the plough, it grows far more produce and employs more labour. The permanent pastures, where they exist in Scotland, usually appear to be neglected and uncared-for, in very striking contrast to the clean and well-tilled arable land that adjoins them.

It would be difficult to say that the difference between English and Scotch farming is a fundamental one. The object in both cases is the same, namely, to make a livelihood from the land; and it stands to reason that the general system must be somewhat similar, though some of the methods employed are almost necessarily different.

Naturally the conditions and methods of farming vary considerably on different parts of each country, but the variations are probably greater in England than in Scotland owing to the far greater diversity of soils and rainfalls. There is one remarkable similarity in both countries that is worth drawing attention to. The Lothians of Scotland and the East Anglian district of England are almost exactly similar in their methods of farming, and have for a hundred years been regarded as the pattern of all that is good in farming; but if one wanted to find the man whom the agricultural depression had never touched, and who had been quietly putting by money while others were being ruined, one would have to get away west of either district, to places where the four-course system had been either abandoned altogether or very considerably modified. [W. M. T.]

Fen Farming

Many persons are prone to believe that the particular portion of the surface of the soil which in their own immediate district passes under the name of the fen, is of an almost similar character to land similarly named in the many other

districts in which it is found in England. The soil and subsoil of the so-called fens vary as greatly as do the soils and subsoils on the higher lands or on those which have not been subject to permanent or temporary floodings, consequently the variations in the systems of farming the so-called fen lands are equally as numerous. The 'Fen Country' proper is in eastern England — Cambridge, Lincoln, Huntingdon, &c. The soil of the fens varies from a black mould to stiff clay; the former after frost and a dry period becomes so light and disintegrated that, if high winds supervene, the land 'blows' to such an extent that the open drains or dykes for drainage purposes are quickly filled, and a large proportion of the soil changes ownership where the properties of two persons adjoin. If this 'blowing', as it is locally termed, is experienced in the winter or spring, the growing crops of beans and wheat or of oats and barley suffer very much, as not only are the blades of the plants cut severely by the fine soil coming forcibly into contact with them, but in those cases where the blowing continues for any length of time the growing plants are uprooted and blown away, or are buried by the drifting soil. When these lands were first brought into cultivation, and even until the prices of cereals became so low that expenditure of all kinds was cut down as much as possible, claying was generally carried out, the plan being to dig openings about 10 or 12 yd. distant, and to dig out the clay subsoil and distribute it over the intervening spaces. The benefits derived from this operation were not confined to the weighting and solidification of the surface soil, but the yield and quality of the corn and root crops were increased. At the period referred to, the four- or five-course system of farming was general; roots such as mangolds, carrots, &c., would be grown and carted off the land, the latter and a large proportion of the former being sold for consumption by dairy cows, and by horses in the large towns. Mustard for seed was also sown in the late spring, or buckwheat, as well as coleseed, which was at times fed off by sheep, or drilled much later and allowed to remain for seed the following spring, the stalks of these two last crops being burned after the seed had been threshed from them. Oats or wheat would follow these crops, a portion of the land being drilled in the late spring with small seeds, Italian and Perennial Rye Grass being the most general. These were usually mown for hay, or the latter would be reserved for seed, whilst the first would furnish a heavy crop of hay and then be saved for seed, while the following crop would be oats. As the major portion of the straw was in many instances also sold off the farm, this was a very exhaustive system of farming, and one which must sooner or later come to an end, the period varying with the amount of plant food which had been stored up in the many years during which the soil had lain dormant. The comparative poverty of the soil which resulted from the continued growth of these exhaustive crops, and the sale of the major portion of them, added to the greatly decreased value of roots, oats, wheat, hay, and straw, led to a change in the system of farming. A greatly increased number of both cattle and sheep were kept as stores, or fattened on the farms by the aid of purchased foods; mixed seeds were sown, and sometimes fed off by fatting sheep, and the roots, hay, and straw more generally consumed on the farm. Then came the boom in potato growing, which led to even a still better system, or a more expensive one, of farming these fen lands. Large quantities of artificial manures are now sown, heavy crops of potatoes being grown, the 'ware', so called, being sent to the towns for consumption, whilst large numbers of pigs are fattened on the over and under sized and 'blighted' potatoes, and meals made from the inferior wheat and barley grown in the fens. This is considered to be an improving system as compared with the older-fashioned system of farming these lands. The growth of the potatoes is so rank that all weeds and twitch are wellnigh smothered and eradicated. In some parts of the Isle of Ely and of the counties of Cambridge, Huntingdon, Norfolk, Lincoln, &c., certain portions of the fen lands were from the first of what is termed a heavier character, and in other parts the soil has become more difficult to plough and cultivate. This may be partially due to the gradual wastage of the humus in the soil, and also to the admixture of the heavier staple of the subsoil with the surface. Instances are known where two horses could plough the newly broken-up land with ease, and now three horses are needed for the same operation. On these fen lands of a heavier character each farmer appears to farm according to his own particular ideas, but at the present time there appears to be less of that almost continuous corn and pulse growing which was not unknown when the prices of those articles were higher. Potatoes enter very largely into the rotation, which is after the five-course shift: thus potatoes, roots, or coleseed; barley or wheat, as the weather in the autumn may determine; part beans and part mixed seeds for mowing once, and then for feeding; wheat followed by oats or barley. The wheat, beans, and oats are generally of fine quality, but the barley is not of malting quality, although frequently a heavy crop. This cereal is either sold for seed or distilling purposes, and on the best-farmed lands much of it is used in the fattening of pigs, and even fed to sheep, or when slightly grown, or as it is termed 'run', being also fed to the farm horses, which thrive well upon it. On some of the richer fen lands potato growing is followed on a very considerable scale, at least half of the acreage of cultivated land being planted each season with seed grown in Scotland, or recently with Irish seed. Until the recent glut in potatoes a large proportion of these crops of potatoes was bought by middlemen, who would employ gangs of men to riddle, sift, and bag the potatoes, the farmer being relieved of all responsibility save the carting of the tubers to the railway station. Again, the growing of considerable acreages of celery and asparagus has become general, whilst on some of the better lands conveniently situated for the railways, broccoli, red cabbages, onions, brussels sprouts, cucumbers, and various other kinds of vegetables are grown.

Some of these are forwarded fresh to the various large towns, whilst other portions are treated on the farm on account of the purveyors of pickles, who enter into contracts with the farmers. On the best and deepest soils, fruit growing is very extensively carried on. This industry is a very important one in the Wisbech and neighbouring districts; strawberries appear to be most successfully cultivated, whilst almost all other kinds of fruit are grown to a greater or less extent. In some districts the holdings are small, and the whole acreage of a portion of these little farms is given over entirely to the growth of fruit and vegetables, the major portion of the labour being supplied by the occupier and his family. In this district the growth of bulbs is increasing rapidly; but the neighbourhood of Spalding in Lincolnshire appears to furnish the larger proportion of the many tons of flowers which are weekly sent off in the season to the various large towns, especially to Manchester, Sheffield, and other manufacturing towns. It is said that the growers of bulbs in Holland already feel the effects of the competition from the growers in the English fens, a competition which promises to become more acute in the near future. This industry is of great benefit in those country districts in which it is carried on, as the returns per acre are very large, and a considerable proportion of it represents labour employed. If the small-holdings system so much spoken of at present is likely to prove a genuine success in any part of the country, it will be within those fen districts where bulb, flower, vegetable, and fruit culture are carried on extensively, since the capital employed is not very large, and is represented to a very great extent by the cost of that labour which can be so well furnished by the holder and his family.

In addition to the cultivated portions of the fens, large areas are in permanent grass, a considerable proportion of it being of fine quality, on which cattle and sheep are fattened with a comparatively small quantity of so-called artificial food, and on which some of the most weighty Shire horses are bred and reared.

It will be readily inferred that the variations in the soil of the fens are at least as great as in all the other portions of the British Isles, that the farmers are equally as progressive, and that owing to this good quality, and to the fact that they have availed themselves to a considerable extent of the natural advantages which they possess, in the readiness of the soil to lend itself to intensive culture and to the growth of those more expensive articles which are in such increased demand on account of the greater earning power of the artisans in the manufacturing districts, the general agricultural depression has not been felt to nearly so great an extent in these districts, the English Fens. [S. S.]

Flower Farming

The cultivation of flowers as a field crop has grown to be a large and important industry. Erfurt, in Germany, is practically surrounded by flower farms, chiefly for the production of seeds, and in Antibes Messrs. Vilmorin & Co. have extensive farms devoted to the same purpose. Likewise in this country there are districts where flowers are grown on a very large scale, either for the supply of seeds, or for use in the manufacture of scent, or to meet the enormous demand there now is for cut flowers for decorative purposes. There are thousands of acres in the London district alone laid down to flower growing, chiefly by market gardeners, and notwithstanding the very low prices they realize, wholesale, flowers thus grown may be called a paying crop. There is necessarily a difference between the cultural methods of the ordinary gardener who grows his flowers in carefully prepared beds and borders, and those of the market and farm flower grower. To all intents and purposes the production of a field crop of certain flowers entails the same outlay as that of an ordinary farm crop of, say, beans or cabbages. The requirements of the plants being understood, it is only then a question of position and suitability of soil. If the flowers are to be cut and marketed, nearness to a large town is an important point. Yet this has proved not to be essential in the case of the Channel and Scilly Islands, where flowers are grown extensively and sent by boat and train for the supply of the London and other markets. If seeds are the object, the whereabouts of the farm does not so much matter; indeed, labour being as a rule cheaper, and the conditions as to atmosphere, &c., being more favourable in situations far removed from a large town, seed farming is preferably conducted in remote country places.

Dealing here with the question of flower farming for market only, we may first consider what are the particular kinds of plants that are best adapted for the purpose. The enterprising grower often makes a good hit by starting something new, which on being marketed readily finds favour, such as, for example, the production of the bright-coloured capsular fruits of *Physalis Franchetti*, which quickly became very popular for winter decoration. There are, however, certain recognized favourites for which there is always a steady demand, market flowers requiring to have certain qualities, such as carrying well, lasting a reasonable time, acceptable colours, and, most important of all perhaps, cheapness. These favourites may be divided into (1) shrubs, (2) herbaceous perennials, (3) annuals, and (4) bulbs. The soil may be of a character that will suit only certain kinds of plants, the best for all purposes being a light sandy loam, as it is easy to work, and by adding manure according to the requirements of the plants it is easily kept fertile. Deep ploughing is sufficient, except in the case of shrubs or deep-rooting perennials, when trenching at the start may be necessary. The spacing of the plants should be with a view to the easy cultivation and cleaning of the ground. For perennials that will remain in the same position several years the plants should be set in rows a yard apart, the distance from each other in the rows being according to habit, generally a foot to 18 in. being the right distance. The plants that are grown thus are Alstrœmerias, Aconites, Asters, *Campanula persicifolia* and its varieties, Centaureas,

Chrysanthemums, Delphiniums, Echinops, Eryngiums, Gypsophila, Helianthus (perennial), Kniphofias, Pæonies, Pea (everlasting), Pyrethrums, Poppies (Oriental), Phloxes, Physalis, Rudbeckias, Solidagos. These are all plants which yield annually a good crop of flowers suitable for use in decoration. Between the rows, in the first and second year after planting, catch crops of quick-growing annuals may be grown, such as Ten-week Stocks, China Asters, Pansies, and Wallflowers, or such vegetables as early turnips, spring cabbages, or lettuce may be made a paying crop if planted early between the rows. Violets are a special culture, directions for which are given under that head. They are largely grown as a field crop in Cornwall and pay well. Bulbs, such as Daffodils, May Tulips, and Gladioli, which are largely cultivated for cut flowers, require to be grown in beds 4 ft. across, separated by paths 18 in. wide. They are planted by first deep ploughing and harrowing the ground, marking out the beds and then taking out about 4 in. of soil from one bed, placing the bulbs in position, Daffodils and Tulips 3 in. apart, Gladiolus 6 in. apart, then taking an equal depth of soil from the next bed and placing it over the bulbs. In this way a large area may be planted expeditiously and cheaply. By setting the bulbs in rows the weeding of the beds is made easier. White and Tiger Lilies are sometimes grown as a field crop, and there is always a demand for their flowers, more especially for the White Lily (*L. candidum*), which pays well in districts where the conditions favour its growth. The flower farmer cannot afford to allow any space to lie idle; he is always sticking in something that will mature quickly, although he does not overlook the fact that the soil must not be overworked. Such plants as Polyanthus, Pinks, Iceland and Shirley Poppies, Sweet Peas, *Gypsophila elegans*, and Sweet Sultans may all be turned to account. With regard to Sweet Peas, the demand for flowers of which has grown enormously in recent years, the first sowing of seeds should be made in February, other sowings being made in March and April. Some growers even sow in November, protecting the seedlings with handlights during cold weather. Late Chrysanthemums are largely grown outside and either lifted and placed under glass to flower, or temporary glass structures are erected over them in late autumn before their flowers begin to expand. There is a great demand for the flowers of early Chrysanthemums from August to October. Dahlias, especially the Cactus section, are extensively grown for the cut-flower trade, their treatment in the field being the same practically as they get in the garden. The production of flowers under glass has become a great industry in certain counties, such as Essex and Kent, where large areas are covered with light glass structures and tender flowers grown in them. This, however, is scarcely what would be termed farming. [W. W.]

Fruit Farming

This branch of farming, in the modern acceptance of the term, is one of growing national importance, and one which is developing rapidly and successfully. The old system of having an unpruned and untended orchard, with trees planted in grass, as an adjunct to the farm, is no longer worthy of consideration as a paying part of a well-managed farm. The produce of such orchards can only be sold at low rates for jam making or cider making, and can find no place in competition with fruit from well-managed orchards. Under these circumstances they require but little notice. Fruit growing is developing into an important branch of farming, and instead of remaining in the hands of market gardeners, it is being taken up by farmers in suitable districts, and a fruit plot of varying size is now a recognized part of the farm in many parts of the British Isles. This change is largely due to the importation of attractive-looking, well-packed, and well-graded samples of fruit from America and from the Continent, which hunted indifferently and badly marketed fruit out of the markets.

Before planting an orchard the farmer must decide on what class of orchard he intends to have—whether it is to be a grass orchard with full-standard trees planted in grass, or an orchard with fruit trees only, and with various crops through the trees, or an orchard with fruit trees and with bush fruit, and strawberries planted between them. The first is the least desirable and least profitable, and takes the longest time to give any return. The last named is the most profitable, and gives quickest returns, but entails intensive cultivation, skilled management, and the initial expense is larger. If fruit growing for market is to be undertaken, the site selected for an orchard must be a suitable one. It is useless trying to grow fruit profitably in dry gravelly soil, in shallow poor soil, or in damp holding, or boggy situations. A good loamy soil is best, but practically any fairly good soil of average depth will do, provided it is properly prepared and cultivated. Apples and pears do well in a limestone district, so also do cherries and plums. If the soil is inclined to be stiff and wet, drainage should be first attended to. Pipe drains are best, and in the end the most economical. The lines of drains should be laid between the main lines of fruit trees, as in this position they are farthest away from the roots of the trees, and the drains can be examined when necessary without interfering with the trees or injuring them. It is not desirable to plant in low-lying situations, or in hollows near ponds or streams, as the trees are liable to be injured by spring frosts. In planting a grass orchard, apples, pears, and plums are usually put down, and in some districts also damsons and cherries. The trees must be full standards, with clear stems of 5 to 6 ft. The apple must be grafted on the Crab, or Free stock, and the pears on the Pear stock. The trees must be planted not less than 30 ft. apart every way, and they should be in regular lines.

Preparation.—Select the longest fence in the ground to be planted, peg off a straight line parallel to this fence and 20 ft. from it at each end. Put in pegs at 30 ft. apart along the line. Mark off a line from end of this and at right

angles to it, and drive in pegs at 30 ft. apart. From peg No. 1 run a line parallel to the first line made, and mark it off at intervals of 30 ft. In this way the whole plot can be marked off into straight lines at regular intervals apart, and all the trees will be in straight lines from whatever angle they are looked at. Holes must be opened at each peg, the holes to be at first planting not less than 3 ft. in diameter, and from 15 to 18 in. deep, according to the nature of the soil. The turves which were taken from the top of the holes may be put in the bottom face downwards, fill in soil to within 10 in. of the top, place the tree in the middle of the hole, having a man at the end of the line to sight it into its exact position, spread the roots out evenly all round, and fill in the soil among the roots. Shake the tree gently to settle the soil round the roots, fill in more soil, and firm gently, pressing with the foot. When all the soil has been replaced, the tree should stand on a slight mound, not in a hollow, the roots should all be well covered, and the neck of the tree, that is the junction of stem and roots, should be just at the level of the surface, not covered up. Deep planting is very detrimental. Standard trees must be staked. A stout stake should be driven firmly into the ground and the tree secured to it, with a piece of old sacking or some straw between the stem and the stake to prevent the former being injured when swayed by wind. This is most important, as if the stems get injured, disease is almost certain to follow. If sheep are to be allowed on the land, each stem must be protected with a bunch of bramble stems, or thorn twigs, or dry bracken, secured round it by wire. Cattle must not be admitted for some years, as they would smash the young trees. The subsequent treatment will be dealt with further on.

In planting an orchard which is to be tilled, the preparation must be more thorough. There is no better method than taking a crop of potatoes out of it the year before it is required. This ensures manuring, cleaning, thorough cultivation, and getting the soil into a good condition for planting. If fruit trees and not small fruit are to be grown, and the intervening spaces utilized for the production of crops or for vegetables, mark off in lines 30 ft. apart, as in the case of a grass orchard. The lines must be pegged at intervals of 12 ft. instead of 30 ft., and holes opened, as already explained, every 12 ft. Two types of trees must be used: (1) half-standards, that is trees with 3 ft. clear stem between roots and branches; (2) bush trees, that is trees with 12 to 18 in. of stem between roots and branches. The half-standard apples must be on the Crab stock, the dwarf bushes on the broad-leaved English Paradise stock. Half-standard pears must be on the Pear stock, dwarf bush pears on the Quince stock. These details are important.

Planting.—Commence each line with a bush tree, and each second tree must be a half-standard. This will leave the half-standards 24 ft. apart in the lines, and 30 ft. between the lines, a distance which will be sufficient for a permanent orchard. The spaces between the lines can be used for any class of crops, and can be worked with a plough. The crops must not come nearer than 3 ft. from the young trees. Apples, plums, pears, damsons, and cherries may be planted, but the order in which they are named indicates the relative desirability of these kinds of fruit for permanent, profitable orchard planting.

The third kind of orchard is that in which fruit, or fruit and vegetables only are to be grown. The ground must be thoroughly prepared, as in the last-described type. Mark off into lines 12 ft. apart, so that the pegs will be 12 ft. apart every way, and all in straight lines from any angle. Open holes at each peg.

Planting.—Half-standards and bush trees must be planted as in the preceding case. Commence the first line with a bush tree, and follow with a half-standard, alternating these up the line. The second line must be planted with bush trees only, the third with bush trees and half-standards, in the same position as line No. 1, and so on alternating lines of bushes and half-standards, and of bushes only. It is most important that these details be observed, as when planted all the half-standards should be 24 ft. apart every way and in straight lines. It will require 75 half-standards and 225 bush trees to plant one statute acre in the manner described. The same kinds of fruit trees may be planted as in the second type of orchard. Now as to spaces between each line. For the first four or five years there will be ample space for three lines of gooseberries, or two lines of black currants, or two lines of raspberries, or four lines of strawberries, between each row of fruit trees. When fully grown these will have to be reduced to two lines of gooseberries, one of black currants, one of raspberries, and four of strawberries, and it will be found better to transplant these small fruits into permanent positions at the end of four years than to put the permanent line down in its true position at first. If special quarters are to be devoted to these fruits, the gooseberries will require not less than 4 ft. every way, black currants 5 ft., raspberries 4 ft. between the rows, and 12 in. between the canes. Strawberries may be in rows 28 in. apart, and 22 in. between the plants. Such planting will not fill the ground for the first year, and there will be space for rows of lettuce, cabbage, cauliflowers, or other vegetables between the lines of bushes. If desired, plants for cut flowers, such as Wallflowers, Anemones, Narcissus, can be grown instead of vegetables, but every available free space should be utilized.

Subsequent Treatment.—Grass Orchard.—Very little need be done in the grass orchard for the first year. The open spaces round each tree must be kept free from weeds, and if a dry summer supervenes, the young trees will require a thorough watering. It is a great mistake to take a crop of hay from a grass orchard. But the grass must not be allowed to grow too long; it should be kept well eaten down by sheep, and fowl may be allowed free access. The long grass tends to smother the young trees, insects find a good breeding place, and the trees

cannot be got at to examine them, or to clean round them, while the grass is long. When the leaves fall, examine all ties and stakes, loosening and refastening the ties; secure the stakes firmly where shaken, and change position of stake where it is injuring the stem. Early in the spring prune the trees, and spray them with the Woburn wash, or with ordinary caustic wash. Spraying should be attended to from the first. As the trees grow, the open spaces round them should be enlarged, and if they are not growing freely, a surfacing of manure should be given.

Cultivated Orchards.—Keep all weeds down, and keep the surface of the soil under the trees free and open. The intervening spaces, where there is room, can be broken up with plough and worked with harrow, but great care must be exercised not to injure the bark of the trees with the swings of the plough or with the horses' collars. Much injury has been done in orchards by neglect in this respect. After leaf fall, the trees must be pruned and sprayed. As the trees grow, more space must be left round them without crops, but such space must be kept clean and open. As the trees are in straight lines, the ground can be cross-ploughed where necessary. Thorough cultivation of the land is of great benefit to the young trees, and if additional space is left free round them each year as they grow, ploughing does no injury to them. No fixed distance can be given, this must depend on the growth made by the trees; but for the first five years the ground covered by the branches should not be ploughed. In fact, it will be impossible to plough this without breaking the branches.

Season for Planting.—Planting may be done from middle of October to end of February, but the earlier it is done the better. All the best trees and plants are cleared out of the nurseries by Christmas, and the purchaser has then to take what he can get. The ground is moist and warm early in the autumn, and the plants quickly become established.

Age of Trees.—When asking for quotations, clear definition must be given to the nurseryman. The type of trees, full standards, half-standards, or bushes must be specified, the kind of stock on which they are to be, and the age. Two years old, or three years old, will be found most advantageous. It is difficult for a cultivator without technical knowledge or training to form trees from maiden plants, and trees over three years old are apt to be stunted. Maiden plants may be purchased at about 45*s.* per hundred, two years old at 70*s.*, and three years old at 85*s.*

Pruning. — The necessity for pruning is a debated question, but it will be found that all really successful growers of high-class fruit prune their trees. Some growers, in addition to the ordinary winter pruning, thin and stop the shoots on the trees in their orchards in July or August. Before planting, each tree should be examined. Four or five branches suitably placed should be retained, the others should be removed. The branches which are retained should be shortened back one-third or half their length according to their vigour, the stronger branches requiring less shortening than weak branches. The laterals or side branches should be shortened back to four or five eyes. The following season the main branches will not require to be shortened more than one quarter of the length of the season's growth, but all laterals which have not formed 'spurs' must be shortened to four or five eyes, and all those which grow inwards, or which cross other shoots, must be removed. 'Spur' is the technical name given to the short gnarled branchlets which carry the fruit buds, and the whole object in pruning is to induce the formation of as many spurs as possible, to have all parts of the tree productive, and to have the 'spurs' in suitable positions on the branches, instead of in a cluster near the ends of the branches, which is generally found in unpruned trees. Another important object is to admit air and light freely to all parts; hence though additional branches must be brought in as the head of the tree or bush spreads, these must be kept far enough apart to allow the laterals on each to develop without crowding, and all superfluous growth must be removed. These instructions, with slight modifications, apply to bush fruit, currants, and gooseberries as well as to fruit trees, but more detailed instructions will be found under each. After pruning, the trees should be sprayed. Spraying is an absolute necessity to keep fruit trees clean and healthy, and to produce good sound fruit. Winter spraying with caustic washes must be completed by the middle of February, as the buds might be injured if sprayed later. The adoption of summer spraying will depend on the presence or absence of insect or fungoid pests. It will be found that fruit plantations which have been regularly sprayed from the first, keep comparatively clean, and give but little trouble.

Marketing.—The disrepute into which home-grown fruit had fallen was largely due to the careless and slovenly manner in which the produce from all but well-worked orchards was gathered and marketed. Such produce had but little chance in competition with the carefully packed and graded fruit sent from abroad. There has been a distinct improvement in recent years, but more requires to be done. Unfortunately there is great want of uniformity in the size and weight of the various packages used in different markets for each variety of fruit, and the peculiarity of each market has to be studied and catered for in order to get the best prices. The general tendency is to reduce the size of the package for first-grade fruit.

Gathering. — Great care must be given to gathering of all fruit. It should all be hand-gathered. Fruit such as apples, pears, and plums should never be shaken from the tree. It must be picked by hand, and be carefully put in baskets or pouches. As these become full or too heavy, the contents must be carefully transferred to larger baskets, boxes, or barrows, for removal to the packing shed. The contents should never be poured roughly from one receptacle to another, as bruised fruit loses in appearance and rapidly deteriorates. In the packing

room the fruit must be graded or sorted into uniform sizes, generally three—firsts, seconds, and thirds, and these must be packed separately. First-class dessert apples and pears are sold in boxes of two to four dozen. First-class cooking apples in similar boxes or flats, or in boxes of 20 and 28 lb., or 40 and 56 lb., according to the market sent to. Seconds and thirds may be packed in bushel or half-bushel sieves. The packing must be honestly done. Discard all damaged fruit, and let all fruit be of even size and the packages of full weight and measure. In some north of England markets fruit is sold by weight only. It is better to pack good dessert fruit in the smaller packages. They are more easily disposed of. Where boxes are used, they may be allowed to go with the fruit. This is a great advantage to the purchaser; the fruit sells more readily, and when nicely packed it commands a better price.

Varieties to plant.—As the varieties of fruit are dealt with under their respective names, not much need be said about them in this article. A list of really good reliable sorts is as follows:—

Apples, Cooking.—Early Victoria, Lord Grosvenor, Duchess of Oldenburgh (for early work), Bismarck, Golden Noble (for mid season), Lord Derby, Bramley's Seedling, Lane's Prince Albert, Newton Wonder (for late work).

Apples, Dessert.—Gladstone, Beauty of Bath (early), Lady Sudeley, Worcester Pearmain (mid season), Cox's Orange Pippin, American Mother, Charles Ross, Blenheim Pippin (late).

Pears.—Beurré d'Amanlis, Doyenné du Comice, Emile d'Heyst, Fertility, Pitmaston Duchess, Williams' Bon Chrétien.

Plums.—Victoria, Early Prolific, Czar, Monarch.

Damsons.—Bradley's King, Farleigh Prolific.

Cherries.—Kentish Bigarreau, Bigarreau Napoleon, Black Heart.

Gooseberries. — Whinham's Industry, Whitesmith, Crown Bob, Keepsake.

Currants, Black.—Boskoop Giant.

Currants, Red.—La Versailles.

Strawberries. — Royal Sovereign, Monarch, Givon's Late Prolific, Sir Joseph Paxton.

Raspberries.—Superlative, Carter's Prolific.

Do not plant too many varieties at first. It is necessary to find which varieties suit the particular soil on which they are to be grown. Unprofitable varieties can be headed back, and be regrafted with those varieties which are useful, healthy, and profitable. Salesmasters like to get an abundant supply of one good variety rather than intermittent supplies of various varieties. Purchasers want to be able to repeat orders for sound and reliable varieties. In planting apples it is not wise to mass the separate varieties, the varieties should be interlined.

[F. M.]

'High' Farming

This subject is also considered under the heading of 'Intensive Farming', and it is not therefore intended to enter at this place upon the minutiæ of intense cultivation. High farming has had its admirers, and has, no doubt, extended in certain directions, especially in connection with live stock. The districts in which it first took root were East Lothian, North Northumberland, Lincolnshire, and Norfolk, all of which counties became famous for the intensity of their cultivation, and the opulence and independence of their tenantry. The same was no doubt observable in other counties, but no one will dispute that each of those above-named boasted a superior class of farming. It was the expressed wish of a former Lord Yarborough to meet his tenants dressed in pink in the hunting field, and Lord Leicester (Coke), the Duke of Bedford, and other noblemen encouraged high farming to the utmost of their power. Mr. Robert Leeds of Lexham informed the present writer that he told Lord Leicester that the subsoil belonged to his lordship, but the soil had been made by the tenants. If anyone wishes to obtain a correct impression of high farming as it was carried out in the middle of the last century, he will find abundant information in The Rural Economy of England and Wales, by Léonce de Lavergne (Blackwood & Sons). It is unfortunately true that the system in which, as Mr. Lavergne declares, the tenant enjoyed the advantages of his land to a greater degree than his landlord, even in those days of high rents, has passed away. He may do so still, but there is less to divide, and the day of high farming has set. Under the heading 'Intensive Farming' many examples are given of successful high-class cultivation, but the objects are no longer, or so exclusively, the production of corn, beef, mutton, and wool. They have been deflected towards pedigree stock breeding, potato growing, fruit farming, and other definite objects, and the consumption of cake for corn has in a manner lost its meaning. The day of high farming in a general sense was coterminous with wheat at 60*s.* per qr. and beef at 8*d.* per lb. It has been pointed out by economists that successive increments in crops are only wrung out of the unwilling soil at an increasing cost for each, and Sir John Lawes during his later years favoured the view that extensive rather than intensive cultivation was the more profitable. To force the production of crops on ordinary arable land, beyond due limits, is not profitable in itself, although it may be a legitimate accompaniment of stock farming on a liberal scale. High farming was at its zenith about 1868, and the names of eminent agriculturists who flourished at that time are too numerous to mention. It was then that the highest hopes were entertained with regard to steam cultivation, agricultural chemistry, and science, and this hopeful attitude continued until 1878. The next year proved a severe blow, and after 1880 prices of agricultural produce went back, and a great movement set in towards laying land under permanent pasture. Say what we will, this is not agriculture, but a relinquishing of the arts of agriculture, in favour of the Prairie. We are living in an era of grass land, and it is inconsistent with high farming in the older sense. We are also living in an age of specialities in farming, inconsistent with regular rotation farming carried on for its own sake.

[J. Wr.]

Hill Farming

Under this designation it is proposed to describe briefly the general character of the system of farming followed on the lower hills bordering the plains as distinguished from that carried on in the prominent ranges and dealt with under the heading 'Sheep-farming in the Highlands'. The scope of hill farming is necessarily limited by the two important factors altitude and exposure, the effects of which on the growth of crops, on the character of the vegetation, and on animal life have already been discussed under these headings. Except in special circumstances, where the proximity to a good market, the character of the soil, or suitability of climate induce intensive methods of cultivation, hill farming is identified with sheep farming and the rearing of those sturdy breeds of cattle such as the Highland, the Galloway, the South Devon, or the Welsh Cattle.

Few crops are grown, only such as are required for the maintenance of the stock. As the soil is generally poor and the growing season short, only the hardiest varieties of fodder plants are capable of cultivation. Of oats, the most suitable and the most extensively grown in upland regions are the Tartarian, and those which belong to the straw-producing varieties — the Sandy and the Tam Finlay. Turnips and swedes are grown to a greater extent wherever the conditions permit. Hay — especially meadow or 'bog' hay as it is often called — is also grown. The whole area under cultivation is small, the arable land being generally confined to a few fields on the lower reaches of the farm. The produce of the land, rendered small through adverse circumstances, and reduced still further by the depredations of ground and winged game, has often to be supplemented by the employment of purchased feedingstuffs.

The greater part of a hill farm is under pasture, the character of which varies with the situation of the farm, the altitude, and the nature of the soil. The nearer the approach to the heather or moor, the poorer the vegetation becomes; yet even here much improvement has been made possible by the construction of efficient hill drains. Much also can be done to improve the quality of the herbage by the judicious application of lime, basic slag, or a combination of basic slag and kainit. Many hill farmers overlook the fact that the sale of wool and mutton annually removes large quantities of fertilizing ingredients such as nitrogen and phosphoric acid and potash—the last two in the carcasses and the first in the wool; and unless these ingredients are restored in the form of manures, the land must undergo a continual process of impoverishment.

Sheep-rearing forms the basis of all hill farming, the breeds best adapted for upland pastures being the Blackface of the Highlands, the Cheviot on the grassy hills of the south of Scotland, the Herdwick and the Limestone Crags in the north of England, the Welsh Mountain Sheep, the Wensleydales and the Dartmoor Sheep in south England, and the Roscommon in Ireland. One of the hardiest and perhaps the most profitable is the Blackface. The rearing of cross lambs is also extensively practised on many hill farms where good shelter is available and the keep good. This branch of hill farming is growing increasingly popular, for the cross lambs mature quicker, and offer better returns than the pure-bred mountain lambs. The management of hill flocks is described below under the heading 'Sheep-farming in the Highlands'. As an adjunct to sheep, the rearing of calves and store cattle is practised on many hill farms. These find a ready market among the farmers of the lowlands. [R. H. L.]

Intensive Farming

This expression is used in apposition to extensive farming. It conveys the idea of high farming both as regards land and live stock, and is naturally confined to densely populated countries. Extensive farming is practised in newly settled lands, where it takes the form of ranching, or of mammoth corn farms where wheat is grown over vast areas without manure, and until the land is worn out. In contrast to colonial systems, our English farming may all be said to be intensive; but in treating of the subject we must regard the expression as applicable to a class of strenuous farming in which fertilizers are applied with lavish hand, and every effort is made to keep production up to the maximum.

Intensive farming has many aspects, and is liable to pass into market gardening and fruit cultivation, neither of which appears to come within the present application of the phrase. It does not include those extremely intense systems involving acres of glass, 'made-up' soils, and artificial heat. Neither does it mean those methods of *petite culture* practised around Paris which have been recommended for the consideration of small holders. All these are well worthy of attention, and certainly come under the title of intensive culture. We shall not in the present connection do more than mention the late General Cotton's plan of deep forking for wheat, with its amazing but incredible results, excepting when restricted to small plots. Neither do we propose to enter upon the results of electric currents underground, nor to electric light overground, nor to sewage farming, nor irrigation by means of hydraulic rams.

Examples of intensive farming are recorded at an early period, and that of Mr. Ellman of Glynde, Sussex, in 1788, is worthy of a first mention. Arthur Young, speaking of the Southdown breed of sheep, wrote: 'I know of no lands in the kingdom, rich marshes excepted, which are stocked in such a proportion. Mr. Ellman, on 500 acres, has 700 ewes, lambs, and wethers in winter, and 1450 of all sorts in summer, besides 140 head of cattle' (Annals of Agriculture, vol. ii, p. 170). The sheep stock alone in this case was far in excess of the one ewe to the acre, with lambs maintained through the summer, generally thought sufficient stock for a hill farm; and the 140 head of cattle in

addition argued a great expenditure upon artificial food, and intense cultivation of root and fodder crops.

It is satisfactory to notice that the Royal Agricultural Society of England has resumed its useful work of reporting upon selected farms, for it is among such that the best examples may be met with of intensive cultivation. Before quoting from any of these reports it may be stated that all the best cases of successful high farming are closely connected with live stock. Cases to the contrary are rare, but under the heading 'Continuous Corn Growing' there is an interesting account of Mr. Prout's proceedings at Sawbridgeworth, and of continuous corn growing at Rothamsted under a very liberal system of manuring. Good examples which have not found their way into print are to be found in Wiltshire and contiguous counties, upon the ram-breeding farms devoted to Hampshire Down sheep. These farms are often of 1000 ac. in extent, and maintain flocks of as many ewes, and also a dairy of cows. The summer sheep stock is naturally double that of the winter, until the lambs are disposed of; and in one case at least, that of Mr. Joseph Dean, late of Chitterne, Codford, Salisbury, the consumption of cake in the height of summer exceeds 1 ton a day. The writer has himself utilized 880 lb. per day on his farm of 534 ac., or at the rate of over 2 tons in five days, previous to the autumnal sales.

An important feature in high-class Wiltshire farming is the devotion of the entire area of wheat stubbles to catch crops. The barley and oat stubbles are sown with clovers or with sainfoin; but the wheat stubbles, which in ordinary farming are winter fallowed for roots, are in this case broken up at once after harvest and apportioned to trifolium, winter barley, winter rye, winter oats, and winter vetches. The farm is therefore one continuous expanse of green in spring without any bare winter fallow. As soon as the sheep have passed over these crops, beginning with the rye, the folds are broken up, and the land is drilled with mangel, swedes, early and late turnips, until once more the fallow breadth is all in roots. The sheep therefore pass twice over the ground in one year, and during most of the time receive cake, corn, and hay. The consequence is extraordinary crops of corn, even on the poorest ground. In this district it is a common practice to 'double-root' the land, and this is accomplished as follows. Once every eight years winter vetches are taken after wheat, and these are followed with late turnips, which afford a fair fold for ewes and lambs in the spring. The land is then broken up and sown with early turnips, which are ready for consumption in August, and is then stocked with lambs receiving cake. The result is that this land has carried sheep three times, and it is then prepared and sown with wheat, the wheat being followed the next year with barley. By this intense system of farming, heavy crops of wheat standing 6 ft. in height and yielding 48 bus. of grain are grown, and that on land not rented higher than 5*s*. per acre. The soil is still rich enough for growing a good crop of eleven or twelve sacks of barley, and the sample is generally of the best quality.

The fertility of the land is almost entirely kept up by sheep folding, and the amount of purchased manures employed is small, and consists of some 2 to 3 cwt. of superphosphate applied to the roots. Nitrate of soda is occasionally used for the second corn crop. The down land is naturally poor and easily run out, so that this system of farming requires to be maintained, and if relinquished, two years is enough to reduce the yield to 24 bus. of wheat or barley and 40 bus. of oats to the acre. This system pays through the sheep, and so liberally are the lands treated that the best 100 wethers are often sold at 56*s*. to 60*s*. per head in August or September. Even those who do not aspire to ram-breeding follow out the same system. In the case of ram-breeders, averages of 10 and 12 gs. per head are realized, and sometimes 80 to 150 gs. for individual lambs; so that in these cases the profit comes directly through the sheep; but in the case of wether-lambs it comes jointly through sheep and corn.

As an example of high or intensive cultivation, the farm of Mr. Teasdale H. Hutchinson, The Manor, Catterick, may be taken. It was the first-prize farm in the competition for 1891, and is situated in one of the most favoured parts of Yorkshire, and is 600 ac. in extent. The chief points to be observed upon, in respect of intensity of cultivation, are the amounts of live stock and of foods and manures purchased. Next come the yields of crops and the rotation pursued. We have little to do with buildings or implements, because some of the best farming in the kingdom is carried on with poor buildings, and implements which may be oldfashioned in construction. Good farming does not consist in externals or in show, but in results; and we therefore pass on to consider this prize farm on its intrinsic merits. The stubbing up of 'miles of fences', and the outlay of £2500 on buildings made by Mr. Hutchinson, although only tenant, are much to his credit, but might be accompanied by bad farming. '*C'est magnifique, mais ce n'est pas l'agriculture.*' On the other hand, clean land, good crops, good stock, and good and profitable management sum up the whole matter, and in all these respects Mr. Hutchinson excels. The total area of about 617 ac. is thus divided:—

Roots	90 ac.
Wheat	51 ,,
Barley	85 ,,
Oats	54 ,,
Clover	68 ,,
Meadow mown	22 ,,
Permanent pasture, ...	247 ,,

The management of the roots is as follows. They consist of swedes, manured with twelve loads of dung turned in with the chill plough. The land is then ridged, the artificial manures sown by hand, the rows split, and the swedes sown with a Scotch drill. The manures broadcasted are: 2 cwt. guano, 2 cwt. bone meal, 2 cwt. rape dust, 1 cwt. kainit, and 1 cwt. nitrate

of soda—8 cwt. in all per acre. This dressing is modified according to circumstances and according to whether dung is applied or withheld. Sowing takes place about April 28, and singling begins about the middle of June. The amount of live stock is thus given, subject to *variations due to sales*:—

28 cows in calf or in milk.
12 heifers served.
54 fat bullocks 2½ to 3 years old.
34 heifers and bullocks rising two years old.
23 yearlings.
6 bulls.

157

10 Shire horses.
7 Clydesdales.
16 hunters.
1 hunter brood mare.
1 hack.
1 pony.

36 horses.

80 pure Leicester ewes to lamb.
145 Border Leicester ewes to lamb.
403 *hoggets.*
8 aged rams.

636 sheep.

Mr. Teasdale Hutchinson is an eminent agriculturist. He is known as an excellent and accredited judge of stock and a breeder of pedigree animals, so that the quality of the animals he maintains is beyond question. The fact that he obtained the first place in a keen competition, renders it unnecessary to expatiate upon the cleanliness and good condition of his farm. He owned, for example, one game cock 'for which it is said he refused £1000'. He had taken £9000 in prizes for cattle, sheep, and horses at the time of the inspections of his farm, and the value of his stock must have amounted to many thousands of pounds. He sells ewes at 20 gs. each, and had just given £94 for a Border Leicester ram. The capital invested in his holding must be extremely large, and we do not venture to assess it. Particulars as to his cake bill and his crops are not supplied in the report, but they are scarcely needed. The entire effect must be pleasing to a visitor, for the buildings are praised as excellent, and the engines, threshing machine, chaff-cutters, pulpers, mills, cake-breaker, hoists, saw-table, and grindstones are all worked by steam, and 'make up a list more for a factory than for a farm'. 'The waste steam is not lost, but is led by a pipe, and used to cook some of the food for the stock. More expensive buildings may be seen, but for completeness and usefulness nothing better could be wanted.' When we consider the value of the herd of fifty Shorthorns, all entered or eligible for the herd book, the value of the *horses, the sheep, and the poultry, this farm* well deserves to stand at the head of a list representing intensive cultivation. It bears out what was stated earlier, that this particular class of high farming is inseparable from high-class live stock, and that good stock and plenty of it is still the backbone of profitable farming.

Lastly, and in proof of the excellence of Mr. Hutchinson's cultivation, the enormous size of the swedes arrested the attention of the judges. Mr. Hutchinson mildly suggested 50 tons per *acre as the yield, and on weighing 100 roots* they were found to turn 76 st., or nearly half a ton. This was actually ·76 st., or 10½ lb. each. With reference to the cleanness of the land it is pronounced 'absolute', and it is further related that one inspector *did* succeed in finding a string of couch, and this he held up in triumph and asked—'What is this?' To which Mr. Hutchinson asked him to find another and he would tell him!

It is to be regretted that the Royal Agricultural Society discontinued its prizes for the best-cultivated farm for several years, as it deprives us of one of the best sources of information on our subject. We must go back to 1888 for a report referring to that excellent group of counties comprising Notts and Lincoln. In the competition, Mr. W. E. Wadsley of Dunsby, Bourne, Lincolnshire, secured the first *prize for the cultivation of his farm of 298 ac.* of heavy land, comprising 180 ac. of arable and 118 ac. of pasture land. The heavy clay soil rests upon gravel and clay. The farm is partly fen, drained under the Black Sluice Act (1846), for which expenditure the land is taxed 6*s.* per acre. The water is drawn off by a centrifugal pump and thrown into the 'Forty-foot River'. Every feature of Mr. Wadsley's farming indicated thorough supervision and careful management. On both the higher and lower portions of the farm a five-course system of (1) mangold and coleseed, (2) oats or barley, (3) wheat, (4) clover, (5) wheat, is followed. The average yields are: wheat 5½, barley 6, oats 9, beans 5 qr., mangolds 41 tons, and swedes 24 tons, per acre. Nine pecks (2¼ bus.) of wheat per acre are sown, and sometimes as little as 7 or 8 pecks. The corn is topdressed with 3 cwt. per acre of dissolved bones. The live stock at the dates of the three inspections by the judges consisted of the following items:—

Stock.	December, 1887.	May, 1888.	June, 1888.
Horses	15	14	14
Foals	—	2	2
Cattle	41	53	45
Sheep	337	328	323
Lambs	—	240	236
Pigs...	7	11	11

On this farm of 300 ac., less 2, it will be noticed that the summer stock amounts to about 560 sheep and 50 cattle. The expenditure on feedingstuffs amounts to £1 per acre over the total area, an amount which is often, it is true, *exceeded, but is nevertheless far above the average.* Like many good farmers, Mr. Wadsley keeps no regular system of books, and it is therefore impossible to ascertain his net profits. He, however, supplied a statement as to his average receipts and expenditures on principal items,

which had been as follows for the previous three years:—

RECEIPTS.

	£	s.	d.
Cattle	422	13	4
Sheep	596	13	4
Horses	45	6	8
Pigs...	30	13	4
Corn (sold)	1027	0	0
Dairy produce	46	13	4
Poultry	25	0	0
	2194	0	0

EXPENDITURE.

	£	s.	d.
Cattle purchased	160	0	0
Sheep ,, ...	320	0	0
Horses	20	0	0
Labour, 25s. per acre	366	0	0
Artificial manures	34	13	4
Seed corn and feedingstuffs ...	318	0	0
Tradesmen's accounts	140	0	0
Rent, rates, and taxes	520	0	0
Gross profit	315	6	8
	2194	0	0

Root cultivation is an important consideration, and mangold occupies a principal position. His average produce over three years was 47 tons per acre, and on the occasion in which he was awarded third prize in competition, 7 ac. yielded 310 tons. Two years previously, the same field produced 52 tons 10 cwt. of mangold per acre. The manuring is heavy, and consists of 30 loads of farmyard manure and 5 cwt. of artificials.

The above cases are all good illustrations of intensive farming, and of thorough cultivation and good management. The gross produce in the case of the last example cited amounts to £7, 7s. per acre, which is at least £2, 7s. in excess of ordinary farming receipts. It must, however, be allowed that the expenditure was also considerably more than in ordinary cases, while the balance of rather over £1 per acre would require to be heavily discounted. We read, for example, of some steam cultivation at 12s. per acre, which is not apparently included in the labour expenditure. The weak point in intensive cultivation is the recognized fact that every increment in produce is wrung out of the land at a greater cost than the last. It is probable that many ordinary farmers make quite as much money from their business as is shown in Mr. Wadsley's case. Mr. Teasdale Hutchinson maintains a stock of animals of extraordinary merits, and, this being the case, the manure is obtained at little or no cost. The ordinary manufacture of beef and mutton and the growth of corn do not appear at present to be qualified to pay for extreme or intensive cultivation. It seems necessary to tack on a speciality, of which there are a great number.

Among these may be mentioned bull-breeding, which entails a pedigree herd of cows. When young bulls can be sold at 30, 40, or 60 gs. per head, the food which they consume is more than paid for, and the manure becomes a simple by-product of great value but costing nothing to produce. Another line is that of ram-breeding. When ram lambs can be sold over £5 each they pay in themselves, whereas fattening tegs leave a debt upon the land which the corn crop must pay. If the statement is true that Mr. Teasdale Hutchinson refused £1000 for a game cock, there seems to be possibilities even in poultry; but if we regard this as an apocryphal statement, we know that 10s., 20s., and higher sums are constantly given for good cockerels and pullets, and that poultry may be at least a supplemental source of profit. Potatoes are now a speciality, as in the case of the Messrs. Dennis of Lincolnshire, who grow hundreds of acres, and send off many truck-loads a day from their farms. Others grow seed potatoes, seed corn, and pure cultures of clover and grass seeds. Horse-breeding is another branch of great potentiality, when backed with capital and judgment. Milk has become a staple on many farms, and is a constant source of revenue. A large dairy will contribute £80 to £100 a month, and during the summer, when milk is at 5d. or 6d. per gallon, will pay £1 per head for four weeks on grass alone. This must pay, and encourage the owner to spend large sums on artificial foods in winter, when the price is 8d. or 9d. Thus manure is produced at the lowest cost, or even absolutely free, and good crops crown the enterprise. Where dairying is carried out to perfection, the butter is in some cases sold at 2s. per lb. instead of 11d. and 1s. Akin to these special means of obtaining manure for nothing (that is, managing so that the live stock pay directly), there are sources of income open to leading agriculturists which are not directly a part of farming, but which assist in keeping up their farms to a high state of perfection. Such are dealing, valuing, umpiring, agency work, &c. Rather more remote are private wealth and trade, which in many cases lie at the foundation of intensive farming. This latter explains the position of those gentlemen who through the indirect assistance of coal, cotton, soap, financial operations, &c., are able to maintain the highest character of live stock, to command high prices, and to take prizes at the great shows. The subject of intense farming seems to include those highly managed farms, equipped with every appliance, such as buildings, machinery, the best implements, the most talented agents and bailiffs, and the most brilliant results both as to stock and crop.

There is a singular case at Rothamsted of land having grown 12½ bus. of wheat, on an average, for seventy years without any manure, while at the same time both the grain and the straw have been annually removed.

This plot of ground shows no signs of becoming exhausted, and appears likely to go on for another seventy years, producing crops which are said to be about equal to the average yield of the wheat-producing land of the world. This is the antithesis of intense cultivation, and it may be asked whether this plot, producing a small but constant return, without any outlay but labour and seed, may not be as profitable as high yields forced by large quantities of expensive fertilizers. The late Sir John Lawes, during his latter years, favoured natural produce of the land in preference to intensive methods. The most singular feature in the unmanured

wheat plot at Rothamsted is, that although it declined for the first few years, it arrived at a sort of bedrock of natural productiveness, which it still maintains. Still more singular is the fact that in the last recorded crop the yield was 18 bus. per acre, which was higher than for many years past, and far above its average. There are other facts connected with this unmanured plot well worthy of consideration. There is a companion plot which has carried wheat for a long series of years alternately with bare fallow; the rotation, if so it may be called, being (1) bare fallow, (2) wheat.

This plot is highly interesting both positively and comparatively, but the net result is in favour of the continuously cropped plot. Taking the period from 1856 to 1905, or for fifty years, the average yield on this plot has been 16·7 bus. per acre, or 4·2 bus. above the continuously cropped plot; but it was obtained off only half of the land. If the simple calculation is made of halving the yield, so as to represent the crop over the entire area, it comes out at 8·4 bus., or 4·1 below the plot constantly cropped with wheat. The results obtained in 1905 are still more remarkable, as in that season the wheat after fallow only produced 12·9 bus. per acre, while the wheat after wheat plot yielded 18!

The conclusion come to is that during the first few years there was a gradual diminution of yield, but later the plot seemed to have touched bottom, and since 1865 to have maintained a constant average, during successive decades, of 11 to 12½ bus. per acre.

Finally, in a good wheat year (1905) it renewed its youth, and produced 3½ bus. an acre more than it averaged in the five years 1851–5, that is, at the outset of the experiment.

In comparison with these results is the adjoining plot, manured every year since 1851 with 14 tons per acre of farmyard manure. This we shall for a moment regard as intensive farming, for this dressing is beyond the power of any farmer as a yearly application to the same land. The result has been a yield of 35·7 bus. per acre over fifty-one years, and a final crop of 38·5 bus. in 1905. That is, an increase of 22·6 bus. over the unmanured plot, which if valued at 30*s.* per quarter amounts to £4, 2*s.* 6*d.* per acre. But 14 tons of farmyard manure could not be produced and applied under ordinary farming conditions for less than 5*s.* per ton, or £3, 10*s.* per acre, leaving a problematical balance of 12*s.* 6*d.* per acre to pay for extra costs on the heavier crop.

We shall take one more case, namely that of the heavily manured plot, which receives 550 lb. of nitrate of soda, 3½ cwt. of superphosphate, 200 lb. of sulphate of potash, besides 100 lb. each of sulphates of soda and magnesia, which last two may be disregarded. The total cost of this heavy dressing would be as follows:—

	£	*s.*	*d.*
550 lb. (¼ ton) of nitrate of soda at £11	2	15	0
3½ cwt. of superphosphate at 3*s.* ...	0	10	6
Say 2 cwt. of sulphate of potash at 10*s.*	1	0	0
Sulphates of soda and magnesia	not valued.		
Total cost of manures	4	5	6

This plot has yielded 30·6 bus. per ac., a return of only 20 bus. over the unmanured plot, which is quite inadequate to pay for the dressing. One more plot is worth attention in this connection, and that is No. 8, which always receives 600 lb. ammonia salts as well as the above-named mineral manures. The cost of this dressing may be estimated as follows:—

	£	*s.*	*d.*
600 lb. of ammonia salts, 5 cwt. 1 qr. 12 lb. at 12*s.*	3	3	6
3½ cwt. of superphosphate at 3*s.* ...	0	10	6
2 cwt. of sulphate of potash at 10*s.* ...	1	0	0
Sulphates of soda and magnesia	not valued.		
Total cost of manures	4	14	0

The average yield from this plot so treated has been higher than any other, and has achieved the unprecedented result of 39·2 bus. per acre during the ten years 1892–1902. It yielded 40·5 bus. in 1905, and land which produces some 40 bus. of wheat per ac. year after year for fifty-one years without failing, and is on the whole increasing its yield decade by decade, must be pronounced to be in a high state of fertility. We shall next look at the balance between expenditure and return, and in doing so we see that there is an average increase due to the manures employed of from 26 to 27 bus. per acre. It represents, in fact, the difference between 12·7 to 13·1 bus. and 39·2 bus. We shall take the higher increase of 27 bus. at 3*s.* 7½*d.* per bushel, which amounts to £4, 17*s.* 10½*d.* per acre. It must, however, be remembered that a heavy dressing of manure cannot be applied for nothing. It also requires much more labour to harvest, thresh, and deliver 40 bus. than 13 bus., and hence we are driven to conclude that this extremely intense cultivation, resulting in a big wheat crop every year, cannot pay much better than the unmanured plot bearing its regular quantum of 12 to 13, or even in some cases 18, bus. per acre. As already pointed out, intensive farming in this country can only pay when the manure necessary for carrying it out is obtained at the lowest possible cost. As soon as ever pounds sterling are to be charged per acre for fertilizing matter, corn at least ceases to pay. We have confined our attention to farming, and declined to enter upon the subject of horticulture, which of course stands on a different footing altogether. Just as the farmer may realize hundreds of guineas for a cow, a bull, or a horse, and thus fertilize his land with food residues which the animals pay for, so the gardener may make a speciality of orchids, carnations, roses, begonias, tulips, &c., and in a similar spirit disregard the cost of artificial manures. Rothamsted, however, clearly shows that although by intense cultivation three ears of corn can be mad to grow in place of one, yet the two extra ears are to be paid for at a cost equal to their value. The cases first cited of Mr. Teasdale Hutchinson and Mr. Wadsley are entirely different, as their abundant crops of corn are produced by food residues left by animals that pay for their food.

It is the same with successful sheep-breeders, fruit farmers, potato growers, seed growers, and

all the specialists already named, and the farms of these, taken collectively, cover an enormous area. It may also be the same with good farmers who breed their own stock, or buy them at favourable times, when they are cheap, and manage them in such a manner as to leave a very small debt upon the manure produced.

[J. Wr.]

Ordinary Mixed Farming

This may be described as common farming in contradistinction to systems which aim at special products, such as potatoes, hops, seed, &c., or high-class live stock. There are many other sorts of farming, such as poultry, sheep, dairy, and fruit farming. Even fox and frog farming are known (see special articles in this work), so that there is no limit to the different classes of farming.

We have in this connection to deal with a system of farming which includes pasture and meadow, and probably a still larger area of tillage land, with horses, cattle, sheep, and pigs, fattening and lean stock, and poultry. It is complicated in its demands both as to knowledge and money, and has suffered more than other branches from the fall in prices.

Farmers who have escaped from the mediocrity of common farming and developed lines of their own are presumably in possession of special ability, soil, or climate, for carrying out their particular object. They secure prices far beyond market quotations, and, in fact, bearing no relation to them. Considerations as to the manurial value of food residues, cost of food, labour, &c., become of comparatively small importance to men who can sell breeding animals for hundreds, or even in some cases for thousands of pounds per head. Such is not common farming, and it contrasts with the humbler task of those who depend for a living upon the narrow margin between the cost of production and market price.

Ordinary mixed farming is less common than formerly. In bygone days, when wheat was worth double its present price and beef was 8½*d.* or 9*d.* per lb., when the price of wool reached 2*s.* 6*d.* per lb., potatoes £13 per ton, and all agricultural produce was dearer than now, mixed farming was not by any means a poor business. There was safety in a number of products, and the more mixed the farming the more secure was the business from failure of crops or of stock. When, however, cereals, wool, beef, and pork fell to recent levels there was a universal panic, and farmers were compelled to alter their methods. The change took several forms, all of which had one point in common, namely, the abandonment of ordinary mixed farming. In many cases the tillage land was converted into grass land. In some, a source of profit was found in the production of milk; in others in an extension of potato growing out of proportion to mixed farming. Farms changed hands and became the centres of horse-breeding, pedigree-stock breeding, seed growing, sheep-farming, dairying, game raising, sporting, &c., all of which encroached upon the area under mixed farming.

If we endeavour to picture the management and economy of a mixed farm, we may do so as follows:—

First there is a fair proportion of arable and pasture land, usually about two-thirds tillage and one-third grass. The tillage land is worked on a three- or four-course rotation, with variations which allow of two-thirds to one-half of the area being under corn. The live stock consists of a few cows, with calves, yearlings, and two-year-olds. The best heifer calves are weaned, and eventually come into the dairy. The rest, and the steer calves, are reared for fattening. A flock of ewes is kept, and the lambs are fattened each winter. A lot of wether lambs is probably purchased late in summer to help to eat off the turnips. Two or three sows and their offspring and a fair number of poultry complete the live stock, unless it also includes a brood mare. There is not scope for a regular shepherd nor cattle nor dairy man, but the shepherding is done by the foreman, and partly by the farmer himself. The cattleman, although fully employed during winter, is engaged in the fields during summer. The cows, pigs, and poultry are managed by the household so far as milking, butter making, egg gathering, feeding the chickens and pigs are concerned.

The farmer takes an active part in the management unless he is in a position to employ a steward, bailiff, or grieve. If not, he gives his own orders, probably measures up the corn, visits and counts the sheep twice daily, attends to calving cows and lambing ewes, waits on sick animals, castrates calves, lambs, and pigs, &c. The sales are varied in character, and include corn, wool, dairy produce, eggs, fat cattle, fat sheep, pigs, potatoes, straw, and possibly apples and other tree fruit.

This system of farming is not extinct, but is less common, for reasons already given, than it was thirty years ago. By its very nature it is widely distributed, for every county supplies land and situations suitable for carrying it out. In order to be successfully prosecuted it requires both skill and industry, and a wide knowledge of everything connected with farming. The farmer must understand the arrangement of labour, the use of implements, barn economy, markets, and all the routine of tillages and live-stock management. It is also important that the land should be good, and moderately rented and rated. It must, however, be confessed that ordinary mixed farming is severely handicapped by the uniform low prices which have prevailed for so many years. To some extent these are balanced by cheaper foods and manures and lower rents; but the proceeds are small, while labour, at all events, is high, and farming of this class must be carefully conducted in order to make for success.

If anyone will take the trouble to schedule the expenses which are incurred in producing a sack of wheat, a fat bullock or sheep, or any calculable form of produce, he will find that good crops and successful feeding are necessary in order to balance the account, and that 'profit' is too often credited in the form of manure values rather than in cash. What appears necessary to

relieve the tension is, a commanding source of revenue, such as a big monthly cheque for milk, or occasional large sums for superior live stock. Many farmers of this class rely upon the sale of one or two good colts without interfering with the character of their farming; but in treating of common or mixed farming it seems necessary to exclude specialities systematically introduced. [J. Wr.]

Market-garden Farming

There can be little doubt that the success of present-day market gardening depends very largely on the amount of practical knowledge and forethought which the cultivator brings to bear on this particular branch of mixed farming, especially as regards the suitability of his soil and locality for the cultivation of various species and varieties of fruit, vegetables, and flowers, while the requirements of the local markets must be carefully studied and correctly estimated. Of recent years many farmers in the vicinity of large towns have entered the ranks of the market gardener with varying success, failure in most cases being the result of inexperience as regards cultural details, coupled with a lack of knowledge of the essentials required for successful marketing.

Market gardening, as associated with farming, is necessarily limited to the cultivation of hardy fruits, vegetables, and flowers, with sufficient under-glass accommodation for propagation; while the forcing of such crops as pay for the extra expenditure entailed in bringing them to maturity at an early date is an important part of the market gardener's business.

The principal hardy fruits cultivated by the market gardener are apples, pears, plums, cherries, currants, gooseberries, strawberries, raspberries, filberts, also peaches, apricots, and nectarines in the more favoured localities of the south of England.

In the cultivation of any particular fruit or variety, every care must be taken to ascertain that the soil is naturally suited for its cultivation, as, if not, the grower will encounter numerous failures and disappointments; moreover, it is never a wise practice to attempt to specialize in too many varieties, more particularly when the area under cultivation is limited.

The cultivation of apples, if carried out on systematic lines, may be considered as fairly profitable: but even though the aspect and soil are all that can be desired, much will depend on the selection of varieties to be grown. Thus in some localities a variety like Lord Suffield is useless, while say Lord Grosvenor may succeed admirably. Wellington, another excellent variety, will not flourish on cold retentive soil; here again Bramley's Seedling might take its place; and many such examples could be enumerated.

Pears are far from being a sure source of profit to the market gardener, except in a few favoured districts. To attempt pear culture in low-lying districts is to court failure; also, to ensure a quick return, all strong-growing varieties must be grafted on the Quince stock.

Plums and cherries are peculiar to certain districts, and to try and establish plantations in some soils is a pure waste of time and money. The soil most suited for plums is one that is scarcely so well adapted for other kinds of fruit, namely a heavy clay loam. Cherries, on the other hand, thrive in deep sandy soil overlying a porous chalk subsoil. Plums require sheltering from strong easterly winds, and for this reason do best in mixed plantations. Standard plums may be planted 20 ft. apart, with bush apples or dwarf plums between at half the distance, the intermediate spaces being allotted to gooseberries or currants.

Damsons are often planted around the sides of plum plantations, as they bear closer planting, and not being so easily damaged by wind, form a profitable shelter hedge.

Gooseberries are a valuable fruit to the market grower, being the first in the season to be gathered, and they have the twofold advantage of being marketable green and ripe. It is always a wise plan to relieve the trees of a certain percentage of green berries, for overcropping with gooseberries, as with all fruits, is attended by a certain amount of injury to the fruiting spurs of the branches. Gooseberries require a moist, porous soil.

Black Currants are a certain crop when planted on moist, strong land, and where the stock can be grown free of the mite which causes the buds to swell to an unnatural size. The secret of success in Black Currants cultivation is a free use of the knife in pruning out old black wood, accompanied by liberal manuring.

There is always a good demand for Red and White Currants, particularly the former; they succeed well in any ordinary soil, and are useful for intercropping with other fruits.

Raspberries are grown extensively as field crops in Kent, Surrey, and the southern districts of Hampshire; they may also be cultivated successfully in mixed plantations under the shade of standard apple trees. Raspberries prefer a rich, deep, and somewhat moist soil; to attempt their cultivation in hot, dry, and poorly nourished soils is hopeless. In field culture the canes are planted in rows 6 ft. apart and 2 ft. from plant to plant, after which they are shortened back to within from 6 to 12 in. from the surface of the soil. A crop of potatoes is usually grown between the rows the first year, as a source of profit and to assist in keeping the soil free from weeds. A plantation of raspberries, if carefully managed, will prove productive for fifteen to twenty years.

Large quantities of raspberries are consigned to the various jam factories in specially constructed tubs, and if not dispatched by fruit trains are sent by passenger, for the fruit soon ferments when placed in bulk.

Strawberry culture is quite an industry of its own in many parts of Kent and Hampshire, where very early crops are obtainable owing to the natural disposition of the land in these districts. As in the cultivation of other fruits, no attempt is made to grow a large number of varieties, a good early, mid-season, and late variety being ample for all purposes. Soft-fruited varieties are practically worthless for

commercial purposes, however rich their flavour. Early supplies, frequent gathering, careful packing, and quick transit are points which tend to make strawberry growing profitable.

Apricots, peaches, and nectarines can only be grown under exceptionally favourable circumstances and in the southern counties of England. Large consignments of choice English-grown fruit reach Covent Garden market from private establishments where it is customary to market all or a portion of the produce grown.

While the demand for vegetables has steadily increased in recent years, this branch of market gardening is a somewhat precarious one, and must be entered upon cautiously by the beginner. The increase of allotments and small holdings is to some extent responsible for a 'glut' in the vegetable market. Near to large towns, farmers frequently set aside several acres for the cultivation of broccoli, Brussels sprouts, cabbage, and other green vegetables, with the result that the crops are frequently sold for a little more than is required to compensate the farmer for labour, and wagon loads are often taken home to be consumed by the live stock of the farm. The most successful vegetable growers are those who, from long experience, know exactly at what time of the year the demand for each particular crop will be greatest, and so likely to yield the largest profit. All who intend to regard vegetable culture as a source of income on the mixed farm will do well to study the forcing of vegetables for market.

In an article such as this it would be unwise to discuss the question of market prices, as these vary so considerably and are never steadfast at any particular season or for any particular crop.

Root crops, as potatoes, beetroot, parsnips, turnips, carrots, &c., all form important market-garden crops, and are grown in fields specially devoted to their culture, and wherein the previous crop has been heavily manured, as would be the case for winter greens, runner beans, celery, onions, &c.

A crop of beetroot is usually very remunerative, provided that a good variety has been sown. As a general rule, turnips are not particularly profitable, but during a hard winter, when greens are scarce, the tops or greens from swedes bring good returns in spring. Of late years large quantities of asparagus have been grown at highly remunerative prices. Peas, broad and runner beans are very often sold at prices which do not cover the cost of cultivation, which is sometimes excessive.

Tomatoes as an open-air crop are not to be relied upon, although in hot dry summers heavy crops of the corrugated or magnum-bonum type can be secured, and cannot fail to be profitable; the unripened green fruit also finds a market for pickling. The smooth-skinned varieties of globular form are, however, preferred by the general public.

Celery is considered to be highly profitable when grown in soil and situations naturally suited to its growth, as in districts along the valley of the Thames. There is always a demand for onions, and here again we find that some districts are especially favourable to their growth, as at Mitcham in Surrey.

Rhubarb is a most important crop, and enormous quantities are disposed of during the spring months. Young crowns of the early varieties are readily forced in hotbeds or in the open field by covering with tubs surrounded by horse litter. In some centres large quantities of rhubarb are grown under fruit trees, in which position it does remarkably well.

In some of the more favourable market-gardening districts around London the French system of gardening is being practised. This consists of an elaborate system of forcing by means of a carefully constructed hotbed composed of horse manure covered by a thin layer of sifted soil, and by the utilization of good friable soil enriched with enormous quantities of well-decomposed manure and leaf mould, the plant covering in each case being a cloche or bell-shaped glass, the standard dimensions of which are 17 in. wide and 15 in. high, capacity 6 gals., and weight about 5 lb. Under these glasses, plants such as lettuces, radishes, cabbages, cauliflowers, endives, melons, strawberries, &c., are rapidly brought to maturity; while many other vegetables and flowers in season and out of season can be produced fresh and sweet. This particular system of gardening requires careful attention to detail as regards watering, ventilation, and protection from frost. See art. INTENSIVE GARDENING.

Vegetable marrows are seen in great abundance in the streets of London during summer and autumn, and are frequently sold at a cheap rate; yet the productiveness of the plant renders it, in favourable seasons, one of the most profitable of all crops.

Mushrooms are largely grown in the open air, on ridges composed of horse manure and covered with a jacket of fine soil; they may also be grown in cold frames during winter. Large quantities of mushrooms grow naturally in old pastures in the south of England, and ofttimes do not pay the cost of marketing; the mushroom grower should aim at placing good supplies on the market just before Christmas, as at that season the demand often exceeds the supply and good prices are realized. See MUSHROOMS, CULTIVATION OF.

Borage, camomile, chicory, dandelions, garlic, gherkins, horse-radish, liquorice, mint, parsley, sage, scorzonera, spinach, thyme, and many other culinary plants and herbs occupy the attention of the market gardener. His choice in their cultivation is largely ruled by public demand, although in some few instances it is possible to popularize some particular fruit, vegetable, flower, or herb, and thus for the time being to ensure for its cultivation appreciable financial success. See art. HERB INDUSTRY.

The market gardener should do as much of his own propagation as is possible, always having abundance of reserve material at his command, for supplies purchased elsewhere are never so satisfactory as those that are home grown.

The fact of young trees having to be lifted and placed on rail tends towards injury and check to their growth; the carriage on roots

for forcing purposes is always excessive, and much damage is done to the crowns. Outlay in the purchase of seeds cannot be avoided, and in all cases the market gardener should procure the very best strains possible, whether of flowers or vegetables.

A large assortment of flowers are grown by the present-day market gardener, but those that come within the scope of the farmer are limited to such as carnations, chrysanthemums, lavender, lily of the valley, Michaelmas daisies, mignonette, narcissi, roses, sweet peas, violets, &c.

It is often found that growers specialize in some particular flower (or, it may be, several), and devote their whole energies to its production, and they themselves are the best judges as to its value from a financial standpoint. See under heading 'Flower Farming' (p. 138) and art. FLOWERS, CULTIVATION OF.

The prices paid for purchase or rent of land adapted for market gardening are ruled to a great extent by its distance from a good market and proximity to a railway station, and by the manner in which the soil has been previously cultivated and manured, thereby making it applicable for purposes of intensive cultivation.

In market-gardening districts rent varies from £3 to £10 per acre, but for what may be termed accommodation ground close to London fancy prices are obtained.

The present-day market gardener must be a shrewd man of business, and be well versed in the most up-to-date methods of packing and marketing, for however well produce may be grown, it is worthless if placed on the market regardless of proper care in grading and packing.

In the majority of cases, salesmen supply packages and all necessary labels, consignment forms, &c., and charge a recognized commission on the sales they are entrusted to execute. See also under heading 'Fruit Farming' (p. 139).

[J. C. N.]

PLEASURE FARMING

For centuries townsmen have liked to buy land in the country and do some farming there, chiefly for the pleasure of the thing. But of recent years a great deal of writing in the press about the country, and more convenient travelling by railway, bicycles, and motor cars, has helped to make pleasure farming even more attractive. The only objection that can be urged against pleasure farming is that it may have the effect of unduly raising the prices of labour and land. Apart from these considerations, it is a thing to be encouraged. It is an excellent thing for the pleasure farmers—they spend their time and money to good purpose, and they have the opportunity of living a healthy life. It is also a good thing for the countryside, for they are the means of spreading among townspeople a better impression of agriculture and some acquaintance with the actual conditions of rural life and industry, and they bring fresh minds, and often minds trained in business, to attack agricultural problems, technical and sociological. Only those unfamiliar with the history of agricultural progress underrate the value of the help which has been given by men who were not bred to farming. Pleasure farming may be carried on, of course, on a large or a small scale. The best counsel which may be properly given to those who would embark on it, on whatever acreage, is to approach the matter as they would the opening of a department of their city business with which they were wholly unacquainted. The first thing that a business man would do in such circumstances would be to decide exactly as to the financial limits of the experiment, and to put the new departure entirely in the hands of the best expert whose services he could command. In plain English, the would-be pleasure farmer should carefully count the cost of the recreation on which he proposes to engage. Then he should spare no pains to secure a bailiff whom he can trust, and, that done, he should trust him until he has reason to do so no longer, and keep his eyes and ears wide open all the time. It is as hopeless for a townsman to enter upon farming in his own strength alone as for a farmer to start in business as a stockbroker or a jeweller. Capital and enlightened views are excellent in their way, but nothing can take the place of experience. If the pleasure farmer, before beginning his experiment, has the benefit of the advice of a skilled agriculturist he is fortunate — that is, if he follows his advice implicitly, and does not allow himself to be carried hither and thither by every wind of doctrine that blows his way. As a business man, the would-be pleasure farmer, after turning over a work like the present, must surely realize that he is face to face with one of the most technical and difficult industries in existence, and that in middle life he cannot expect to enter it with the expectation of profit. Even if he did make a profit, the improvements he makes must eat it up. Not that the improvements are not worth making. Of course they are. But a business cannot be managed on the lines of a recreation. With foresight and shrewdness, business skill and ordinary good fortune, the pleasure farmer, in possession of an honest, competent, and interested bailiff, can have, in return for his expenditure, one of the most interesting of recreations, he can live a useful and full life, he can enjoy the pleasures of the country, and, while he can hardly expect to make money, he need not, in the long run, be out of pocket to any considerable extent. No doubt a man who lives on his farm all the year round will learn more of farming than a mere week-ender in the country; but it must be many years before a townsman in possession of land can have any skill to speak of in the buying and selling of stock and crops and in the working of the soil, so as to win to the utmost the cooperation of the weather and of the bacterial life and chemical processes of the soil. In these matters, everyday practice and what can be learnt out of books are miles apart.

['H. C.']

POULTRY FARMING

The common acceptation of the term 'poultry farming' is a very erroneous one. In the minds of many people, both agriculturists and others,

it represents ground absolutely and entirely covered with poultry runs, kept in large numbers upon the same soil year after year. This acceptation of the term poultry farming is certainly misleading. That may be poultry keeping, but it is not poultry farming any more than the covering of ground with sheds and open courts in which milk cows were kept would be dairy farming. We must therefore regard this term very much more widely, and apply to it exactly the same principles as we should in the case of larger stock. Our meaning of poultry farming is that poultry is the leading object, but that farming, including the cultivation of the ground, shall enter into the business. For that reason, it will be understood that poultry farming involves much more than does ordinary poultry keeping.

In this connection it is necessary to remember that the food supply of any country must depend upon farmers. This is as true of poultry keeping as of anything else, and without the development of and increase in the number of poultry in relation to general agriculture, the amount of production would be comparatively small. That is so in France, in Denmark, in Britain, and in Belgium, as well as in every other country with which we are familiar. Attempts have been made, however, in this country to deal with the matter on a different basis, but they have failed. It is from America, however, that we have heard most with regard to the great poultry plants, at some of which several thousand laying hens are kept, and it may be thought that these contribute largely to the food supply so far as eggs and poultry are concerned. Such is not the case. That they have an influence is undoubted, but during careful observations in America we found that more than 95 per cent of the eggs and chickens marketed are produced by ordinary farmers and as part of their general operations. These special farms have undoubtedly a place, but it is a minor one, and we must look chiefly to the ordinary farms of the country for supply of what we need in this direction. That poultry production is capable of great extension, even upon farms, is evident. The latest figures available show that in Britain there are probably not more than 700 or 800 fowls per 1000 ac. of cultivated land, and it would be comparatively easy to multiply that number fourfold without interference with any other stock or the present methods of cultivation. In fact, it would be an addition to the crop, not only seen in the actual sales of eggs and poultry produce, but in the manure supplied to the soil. Within recent years more attention has been paid to poultry keeping than ever before, and we may anticipate that this will be increasingly so in the future. The important point, however, is that it shall be carried out upon right principles.

As already stated, poultry should be only one part of the stock, but they must be properly looked after. They require even greater attention than larger animals, due to the fact that they are quicker in growth, and the number kept is generally much greater. There are seasons of the year when the poultry require a very small amount of attention; but at other periods, if success is to be achieved, then they must be well looked after. This is especially the case during the rearing periods of the year. If the most satisfactory results are to be obtained in the sale of produce, the collection and marketing of the eggs and chickens needs to be done at the time and in the manner by which they will yield the best returns. At one time a common plan was for the farmer simply to keep a number of fowls around the homestead, and so long as that number was limited no better system could be devised. Such a system was not, however, upon commercial lines. The birds were accommodated either in one of the permanent buildings or in a special house, and they had to find a large amount of their own food; but as soon as numbers were increased some other system became essential. Otherwise the ground around the homestead would speedily become tainted by the manure produced, and disease would result. The method adopted in America has been to put down permanent houses with runs, and to some extent in Europe also; but one explanation of the great development of poultry keeping in this country has been the adoption of what is known as the portable-house system. These houses or huts are made of wood, generally about 6 ft. square, about 5 to 6 ft. high, and in many cases fitted upon wheels or runners, so that they can be easily moved about the farm. For larger houses, it is better to make them in sections, so that they can be taken down and fitted together again. The former, however, facilitate moving, but the latter may be used where it is only intended to change the ground two or three times a year. In this way the birds can be scattered over the ground in accordance with the rotation of crops. They find a large amount of food, and at the same time the manure is distributed under circumstances which yield the best results. It may be pointed out that the manurial value of fowls is very considerable. Experiments conducted at the College Poultry Farm, Theale, have shown that 25 of the larger-bodied fowls will produce a ton of moist manure in the course of twelve months, and that the manurial value per fowl is equal to about thirteenpence to fourteenpence per annum. That, of course, involves utilization of the manure, which cannot be better than under the system described above. Sometimes, however, fixed houses are found to be desirable, and they have a convenience under certain conditions, though not, as a rule, by farmers. Still, when required they may be very valuable, especially for breeding pens. The danger in this case is from tainted soil, and care should be taken to give large runs, which must be kept closely cropped, otherwise the manure will not be utilized.

The branch of poultry farming which is taken up will depend to some extent upon demand, but there is no reason whatever why egg production, chicken rearing, duck breeding, and turkey raising should not be carried out by farmers much more largely than is the case at present.

Another system which promises to yield very

considerable results in the future is known as the colony house system, and in those districts where vermin of various kinds are troublesome it has manifest advantages, whilst it also facilitates labour. Briefly stated, this system is that a field is given up entirely to the poultry for one or two years, and it is thickly stocked. Upon grass land 100 birds can be kept to the acre, but upon arable land as many as 200 birds to the acre. These are accommodated in houses, each holding 30 to 40 birds, and at the end of one or two years, as the case may be, the whole of the flock is transferred to another field, which is occupied in the same way, that vacated being cultivated in one form or another and not occupied again by poultry for three or four years, which time is required to exhaust the manure placed into the soil. From what has already been stated it will be seen that this amount is large. With 100 birds to the acre there will be added 4 tons of moist manure, and with 200 birds double that quantity. Under these circumstances it will be evident that management is greatly simplified. Instead of attendants having to walk all over the farm to the separate portable houses, the work is concentrated. No separate runs are given for the birds, as they all go together; but where foxes and other vermin are troublesome the entire space occupied can be fenced with wire netting, and removed at the end of the time named. Another plan which has been steadily advancing in favour in England is known as running fowls on farmers' land. In some districts where the occupiers themselves do not care to take up poultry keeping—and this is true within certain areas—they make arrangements with poultry keepers for the birds of the latter to run over their land, and in this way the production of the country is stimulated, whilst the enterprise is divided. The common charge made is that a rent is paid of 10*s*. per house holding not more than 25 fowls. The poultry keeper has access to the land, but must move his houses about in accordance with the requirements of the farmer. This plan is one which can be commended in many districts.

The supreme question in the United Kingdom for all who take up poultry keeping is not so much climate as soil. Experience has proved that eggs can be produced on all soils, and the better the soil the better the quality of the egg; but chickens grow slowly upon cold, heavy land, and consequently the last-named conditions are unfavourable to the production of table fowls and also to turkeys, both of which require a kindly soil, one which is naturally dry, and yet at the same time good in its vegetable growth. Experience has shown that it takes three to four weeks longer to grow a chicken to killing age upon heavy land than upon the lighter soils, and when grown it is not nearly so good in quality of flesh. Under these circumstances, it will be evident that whilst eggs may be produced in almost any part of the country, there are considerable limitations as to the best quality of table fowls. It must not be imagined, however, that sandy soils are good, even though they be dry, for the reason that there is a very small amount of natural food in them, and whatever vegetable growth is found proves to be of small nutritive value. Something, however, depends upon local markets, because it is useless producing what cannot be sold at good prices, and as eggs are largely in demand almost everywhere, the production on that side is much the greater. In those districts which are contiguous to the great centres of population there is no difficulty as to sale of produce, but in the purely agricultural sections of the country, organization for marketing becomes an essential factor in attainment of success. It is with this object in view that the National Poultry Organization Society has advocated the adoption of co-operation amongst producers for the sale of their eggs and chickens.

From what has been already stated, it may be assumed that there is no place for what are termed special poultry farms. That, however, would be erroneous. In America, as well as in our country, these have grown largely of late years; but experience has shown that they do not yield adequate returns in production merely for market, by reason of greater capital expenditure required, and also for labour. In America the bulk of these make a leading feature of sale of stock birds, eggs for hatching, day-old chickens, &c., which, of course, yield very much higher returns than as food supply. In this way the additional expenses involved are provided for. These breeding farms are absolutely necessary. The same principles may be observed in connection with them as already noted, that is as to soil, &c., and wherever there can be a combination of fixed houses with open fields, the latter to be occupied either by portable poultry houses or colony houses, the greater is the success attained. It is to these breeding farms that we look for improvement of the economic qualities of the fowls, and for the preservation of the racial characters. The ordinary farmer cannot undertake such things as trap-nesting, &c., which are necessary to that selection of the stock birds, without which increased production cannot be achieved. They have had a very great influence upon the improvement of the economic qualities, and the ideal state of things is that farmers in any district would be depended upon for the great bulk of the supplies, but that to the breeding farms they would look to secure the fresh stock necessary, and for the development of the egg and table qualities which are necessary to yield the greatest amount of profit. [E. B.]

Several publications are in circulation, and articles appear in the periodical press from time to time, which encourage the launching of poultry-farming schemes on other than the sane lines laid down in the preceding article. A system has also grown up in some poultry papers in this country and America of printing illustrated accounts of poultry farms of a commendatory character, which many readers fail to realize are paid-for advertisements. In view of these facts, the belief in the existence in the United Kingdom and in the States of profitable poultry farms, arranged on lines that every acknowledged expert has no doubt are hopelessly

uneconomic, is extensive and extremely difficult to eradicate. The belief is strengthened in the minds of many persons by the evidence of their eyesight. All over the country there may be seen, apparently in flourishing circumstances, these poultry farms which it is asserted cannot be made to pay. It is necessary, therefore, to explain how they come to be in existence. Nearly all of them, to begin with, are owned by ex-townsmen or ex-townswomen, who can only become acquainted with their ignorance by experience, and the most of them last, under the original direction, for a very short time indeed. Those which do not die at once are largely supported by the premiums paid for 'pupils'. Very few of these establishments are without this remunerative source of revenue. Many poultry farmers' favourable balance sheets are obtained by neglecting to charge the accounts with the proprietor's salary and dividend. Sometimes poultry fattening, which with skill and business aptitude can be made to pay well, is developed. No balance sheet for five years, showing a reasonable profit, has ever been forthcoming, however, from a poultry farm in this country devoted to the raising of table chickens or breakfast eggs only.

When we come to poultry farming combined with other stock keeping or the working of the land for fruit or other crops, stress needs to be laid on the fact that knowledge not only of poultry keeping but of these other branches is called for, and that every year the standard of information required is higher. There is no profitable market nowadays for second-rate fruit and vegetables, for example. Such an equipment of special knowledge is not usually the possession of the townsman turned countryman. It is obvious, however, that many farmers' sons and daughters are much better placed to understand their shortcomings in the matter of technical experience, and to make good their deficiencies if they wish to do so. Many things point to the future of poultry farming belonging to the intelligent sons and daughters of farmers. That specialist poultry farms, that is, establishments devoted largely to the rearing of stock birds—an increasingly complicated business if a high laying average is wanted—or even day-old chicks, have an opening before them in favourable conditions is also plain, and here again the sons and daughters of farmers have exceptional advantages for entering the business. On a farm many expenses of a poultry farmer can be met at a nominal cost. With a troublesome small stock like poultry it is imperative to keep the labour bill at a minimum, practically to abolish rent, and to procure food in the most advantageous way. The great opportunity of poultry farming in this country seems to be as a branch of ordinary farming. On farms where a member of the family has taken over and developed the poultry branch, as another may take in hand the dairy, the bees, or the garden and the fruit, excellent financial results have followed in many cases. It is desirable, of course, that the poultry operated with should be of the best possible breeds for egg or table production, as may be required, and that the maintenance of a high level of economic qualities should be regarded as important. Farmers who are desirous of giving some attention to the development of the poultry branch would do well to place the son or daughter into whose charge it is to be given in the way of obtaining a thoroughly up-to-date acquaintance with the requirements of the egg and the table-bird trades. These trades are more complicated than many agriculturists seem to imagine. It is certainly impossible to command the highest prices without being closely in touch with the precise requirements of the markets. Favourable climatic conditions count for much in successful poultry work, but technical experience is even more important. The experience of the egg depots and the Heathfield fatters show how much is to be gained by the best methods. There has been much wild talk as to the possibility of producing in this country the eggs imported from abroad. As a matter of fact, many millions of these oversea eggs are imperatively necessary to our manufactures and for other purposes; but there still remains, particularly at a time when our people are appreciating a lighter form of diet, an opening for the production of much larger quantities of eggs and table birds on the farms of the United Kingdom than are now marketed.

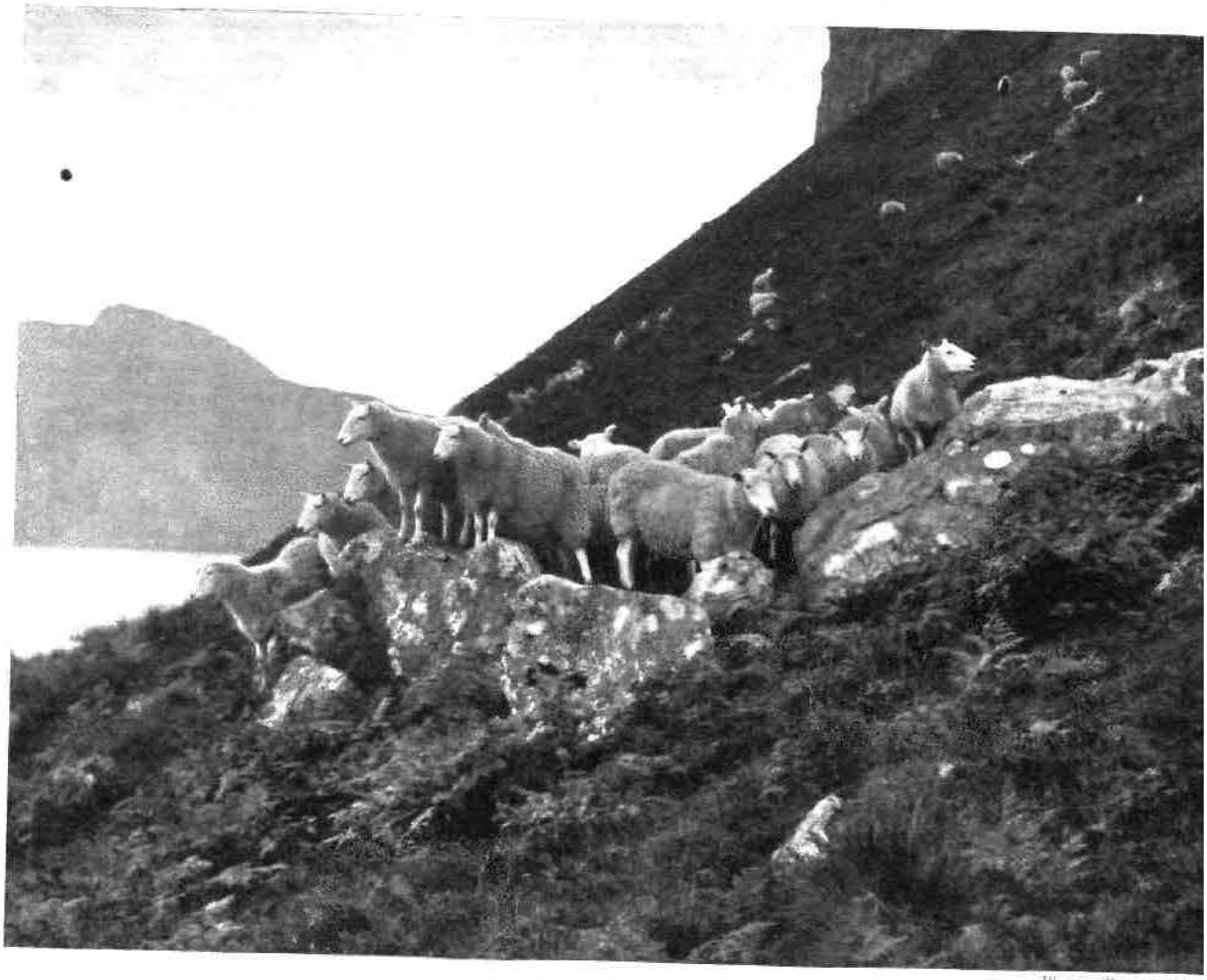
['H. C.']

Sheep-farming in the Highlands

When it is stated that there are about 840,000 sheep in Argyllshire, 660,000 in Perth, 535,000 in Inverness, 263,000 in Ross and Cromarty, 196,000 in Sutherland, and 125,000 in Caithness, it is seen how important is the sheep-farming industry in the north of Scotland. It is impossible to say what are the relative numbers of the different breeds to be found in the various counties. Practical men who have made returns to Government (Report on Wool Production in Great Britain in 1905–6) differ considerably in their estimate, but generally speaking it may be said that Blackfaced sheep are in an overwhelming majority in Argyll and Perthshire. In Caithness and Sutherland the majority will rest with the Cheviots. In Inverness and Ross-shire the numbers will be fairly equal. Besides these breeds, a few crosses and half-breds are to be found in many of the districts, the half-breds of Caithness being specially noted.

Sheep-farming proper, so far as the north of Scotland is concerned, is of comparatively recent date. Sir John Lockhart Ross of Balnagowan, about 1775, was the first to introduce sheep-farming into Ross-shire, and it is stated (Transactions of the Highland and Agricultural Society, 1887) he was for seven years thereafter the only sheep-farmer in the county of Ross, if not indeed in the whole range of country north of Aberdeen. The efforts of the laird of Balnagowan, and others who in the different counties adopted the same policy, met with strong opposition from the natives, who believed that the land was for people, not for sheep: but by the beginning of the 19th century the sheep-farming industry was fairly established. Undoubtedly the population of certain districts was reduced, but, on the whole, sheep have proved an immense boon to

SHEEP-FARMING IN THE HIGHLANDS



ON THE MOUNTAINS

Photo. Chas. Reid

BY THE SEA

Photo. Chas. Reid

the whole north of Scotland. The Messrs. M'Kay, long tenants of Melness, the largest farm in the county of Sutherland, and probably in the kingdom, were descendants of a crofter who was 'cleared' off part of Melness when sheep-farming was first introduced. By indomitable perseverance, tact, and ability, it is said the Messrs. M'Kay rose to be, in regard to acreage, the most extensive sheep-farmers in the United Kingdom.

It was with Blackfaces that the first experiments in stocking the Highlands were made, but in the early years of the past century Cheviots were introduced, especially to Sutherland, and speedily multiplied. About that time, scab and rot had killed the majority of the small and ill-shaped Kerry sheep which along with the black cattle had previously grazed the straths and mountains. Messrs. Atkinson and Marshall at that time brought a very fine stock of Cheviots from Northumberland into the county, and this was the beginning of the industry which gives to the county of Sutherland its agricultural wealth and greatness.

To Caithness, Cheviot sheep had been introduced even earlier, Sir John Sinclair bringing a considerable number north in the year 1790 (see art. CHEVIOT SHEEP). About the middle of the 18th century, Blackfaces had found their way into Perthshire, and probably also into Argyll and Inverness. In the Farmers' Magazine there is mention made of Mr. John Campbell of Lagwine, 'who', about 1755, 'was certainly the first who banished cattle from the West Highland hills and supplied their place with Blackfaced muir sheep from his native parts' (Transactions of the Highland and Agricultural Society, 1884).

Sheep of good class having been introduced, the intelligent and shrewd men of the north quickly realized their value, and many farmers from the lowland counties became tenants of grazings on the farther side of the Grampians. Among those who were prominent in the earlier days were Mr. Patrick Sellar; Sir John Sinclair; Major Clunes, Cracaig; Mr. John Clarke, Eriboll; Mr. James Hill, Sciberscross; Mr. William Innes, Sandside; Mr. Mundell, Inverhaul; Mr. Cameron, Culcairn; and Mr. Mitchell, Tulloch: some of these being natives of the Highlands, others going north to seek their fortune.

During the earlier years of the 19th century the numbers of sheep in the Highlands, and indeed throughout Scotland, increased rapidly; but during the latter half of the century a demand arose for deer forests, and as many crofts and crofters had been displaced in former years by the advent of the sheep, so now many sheep had to give way to the advent of the deer, and the English or American sportsman. By 1873 it was estimated that 400,000 sheep had been cleared off the different 'forests', which were then said to number between sixty and seventy. Now many more 'forests' exist, and the number of the sheep displaced has been largely increased. The area now under deer is said to amount to 3 million acres, five-sixths of which is in the counties of Ross, Inverness, Argyll, and Sutherland.

In the 'seventies and earlier, wool was one of the main items the sheep-farmer had to sell, and Highland wool, specially the Cheviot of Sutherland and Caithness, was a most valuable asset. The price got for the clip made it possible to keep wether sheep till they were three years old, when, having attained their prime, they came off their grazings in October ready for the butcher. Since the great fall in the price of wool which occurred in the early 'eighties, it has not been at all profitable to keep eild sheep, whose only return was their fleece, and in most cases it has been the land which used to be grazed by the wedders that has been put under deer. There are still some Cheviot and Blackfaced aged wethers kept, but the number is inconsiderable compared with what it was twenty-five or thirty years ago. The desire for younger mutton and lighter carcasses co-operated with the low returns for wool and the demand for deer in bringing about this result. In the west of Inverness-shire—through Lochiel's country—where the stocks are principally Cheviot, and in Argyllshire, 'afforestation' has not taken place to the same extent as in certain other counties. Nor has there been extensive clearing of sheep in Perthshire except on its west side, where considerable tracts on the Breadalbane estates have lately been given over to sport. It is computed that almost as many men are employed in one capacity or other when the land is under deer as when it carries sheep, and it is certain that increased rents have been secured by the landlords by the change. One of the effects of the extensive clearances for deer has been to help to inflate the values of the remaining sheep stocks. Notwithstanding the variation from year to year in the prices got for the ewes and lambs that are sold off the farm, the values of the stocks which have passed from the outgoing tenant to the incoming, or to the landlord, as the case may be, have kept steadily rising during the last half-century. One farmer in 1859 paid—price fixed by arbitration—£26 per 21 ewes and lambs on the holding he was then entering. On going out in 1878 the price fixed in the same way was £54. His experience would be typical; and the average price in the year 1908 for ewes and lambs would not be less than £60 per 21. Considering the price got for the lambs, probably 10*s.* to 12*s.*, and for the cast ewe, say 18*s.* to 20*s.*, and for the wool—at 4*d.* per lb.—1*s.* 4*d.* to 1*s.* 6*d.* per sheep, the price (£60) to the ingoing tenant or landlord can only be called inflated. At the same time, however, if a fair and reasonable price is arrived at, all are agreed that it is essential that where the farms are to be continued as sheep-walks, the stock should be bound to the ground. Sheep are of more value on the land on which they have been reared at Whitsunday of any year, than they are to be driven off. A considerable proportion of the Highland sheep land, and especially of Argyllshire (owing to a certain extent to the dampness of climate), is unhealthy—that is, the sheep on it are subject to braxy, trembling, and other ills to which sheep are liable—and new sheep brought on are much more easily affected than those reared on the ground. In a great many cases the farms are

unfenced, the boundary line between one farm and another being marked by a small stream or other easily crossed and perhaps wholly imaginary line. The sheep bred on the ground seem to know by instinct their own territory, which strange or brought-on sheep cannot do; consequently, in the attempt to 'heft' the strangers, continual and constant herding is needed for a long time, and even with the utmost care many wander away and are eventually lost. Besides, the land in many cases is so rugged, and the streams and rivers so swift, that there is always a certain amount of loss which can never be accounted for. It will be easily understood that newly-brought-on sheep are much more liable to accident than the natives. These and other considerations justify the fixing of a price higher than 'market value', but most will concede that many Highland valuers take an extreme view.

The management of farms in the north does not differ materially from that of similar holdings in the south. Old customs die harder, perhaps, but railway facilities and other means of transit are opening up the country, making interchange of stock easier, and bringing the various commodities required by the farmer within reach. The practice of smearing the sheep, now entirely discontinued, lasted many years longer in the north than in the south. A mixture of tar and butter, or other greasy matter, was carefully and laboriously applied to the skin of each sheep, which was in this way thought to be prepared for the rigours of the coming winter. The operation was performed in October or November. So slow was the process that an expert smearer could only do twenty sheep in a day, and even with extra hands engaged, a whole month would be occupied in overhauling the stocks. The fishermen of Skye were in many cases clever smearers, and numbers of them found remunerative employment at this work during a part of their slack season. From 1880 smearing became uncommon, and from 1885 it may be said to have been entirely discontinued. Dipping is now general twice a year; in fact by the present regulations of the Board of Agriculture it is compulsory. The result of the stringent rules enforced has been that scab, which was so long exceedingly prevalent in the Highlands and Islands, has been greatly reduced, and it is expected confidently that it will soon be extinct.

One of the great events of the sheep-farmer's year is the Inverness Fair—for the sale of stock and wool—which is held in the middle of July. This old-established character fair rules the prices to a considerable extent not only for the Highlands, but for the whole of Scotland. Fewer transactions are now made at Inverness than formerly; still there is a great amount of business of one kind and another done. Of course, no sheep are on view at this fair, all dealing between buyer and seller being done by the reputation or 'character' of the ewes, or wethers, or lambs, as the case may be. The railways make it more easy nowadays to have large sales by auction in August, September, or October, when the stock is ready to be removed from the grazings; consequently many farmers and dealers—both buyers and sellers—think it more satisfactory to 'expose' the sheep at one or other of the centres where sales are held—at Lairg, Inverness, or Perth. However, thousands of ewes, specially Cheviots, are still sold annually from Ross, Sutherland, and Caithness at Inverness Fair to buyers from the south of Scotland and England. At Lairg (Sutherland), in August, 3000 to 4000 Cheviot wether lambs will be annually sold, and about the same number of ewes towards the end of September. Probably twice those numbers are sold by auction at Inverness sales in August and September from the counties north and west of that centre. Those in the districts south of Inverness do less selling there, preferring the sales at Kingussie and Perth, to which the largest lots of Blackfaced lambs and ewes are sent.

Lambing commences, generally speaking, towards the end of April on the Highland farms, and 16 to 17 lambs to the 20 ewes is considered a fair crop. The lambs are marked about the middle of June, and there is not a big death-rate among them until October, when, if they are not sent off to wintering, many die of braxy. This is the disease which is most common throughout the north, but certain districts —west Perthshire and Argyllshire, for example —suffer greatly from trembling, both in the case of ewes and lambs, in addition. One gentleman who occupied a holding in Argyllshire, carrying 125 scores of ewes, lost in one year 501 sheep by these two diseases. This was his worst experience during his lease, but he says his average annual death-rate was well over 10 per cent. His experience may have been worse than that of most farmers, but there is no doubt whatever that very considerable loss by death is experienced every year in many districts.

In Caithness and Sutherland, in the west of Ross and in Skye, the sheep for the most part run over the whole of a farm, or rather over the whole of a hirsel of a farm. Elsewhere the ewes, during four or five months of summer, go on the highest portions of the farms, but are kept on the arable and lower grounds from October till June, or in some cases July, of the following year. This is a comparatively new practice, occasioned by the necessity of having the lambs, especially the wethers, as full of condition as possible for the August sales. In former years, when so many wether lambs were retained by their breeders, it was of less moment whether they were fat or lean at weaning time; now the price obtained at an auction sale depends very largely on the bloom and condition in which the lambs are when they are shown.

For purely sheep farms carrying ordinary Blackfaced stock, the rents will average about 2*s.* per ewe; but considerably more will be paid where good Cheviots can be grazed, 4*s.* to 7*s.* per ewe being given as the rent by some large farmers in Sutherland. The hoggs, and often a number of the gimmers, which for the most part are kept eild, are wintered away. As has been pointed out above, the death-rate among young sheep would be excessive if they were kept at home during their first winter. The price of wintering may now be stated as about 6*s.* each. This

is found in Aberdeenshire, Ross-shire, Moray-shire, Banff, Nairn, and other counties which have more arable land and proportionally fewer sheep.

Not only has the Highland farmer much loss by means of the diseases common to sheep, such as braxy, louping ill, rot, &c., but the winter storms cause him in many seasons much anxiety. It is generally accepted that it is a mistake to feed hill sheep with artificial food if it can be at all avoided. When it is possible to procure it, every farm should have a good supply of bog hay, which, when the snow lies hard on the ground or is too deep to be workable, can be fed to the sheep. Farmers and shepherds are careful all through the winter and spring months to 'draw in' for special care and feeding all sheep—especially of the younger ages—which show signs of thinness or weakness, and in this way loss to a great extent is avoided, and the death-rate reduced. See also arts. on BLACKFACE SHEEP and CHEVIOT SHEEP. [W. B.]

SHEEP-FARMING ON LIGHT SOILS

Owners of large flocks of sheep are always, and with good reason, considered to be wealthy. Sheep are not superabundant either in this country or in the world generally, and for many years past have maintained their market value. Sheep-farming is associated with mountain slopes and unenclosed downs, but is also extensively carried on upon cultivated land; and it is this class of occupation which we propose to treat of at present. Sheep are found on all classes of soil except the very heaviest. There are breeds of sheep which do well upon low-lying rich land, and others which are suitable for higher and drier situations. Sheep are associated with light and high-lying land, just as cattle are mostly found on heavy soils and in rich valleys. Both descriptions of stock are, however, found in company, in all districts of a mixed character, and it would be useless to pretend to limit them to particular areas. In a vast number of cases sheep are dispersed among cattle, and the system employed is that of open grazing. The management is not of a definite character, and consists in supervision during summer, and folding on turnips during winter. This is not sheep-farming in the sense understood in the present connection, but is only a part of a mixed system of farming.

Sheep-farming on light land evidently involves arable cultivation, and not the mere grazing of sheep on hills or open downs. Originally it no doubt took this form, but the introduction of turnip crop during the 18th century modified the management of flocks. If we regard sheep-farming on light lands as a definite system, apart from the mere keeping of a mixed stock of cattle and sheep, it will be found associated with certain districts of a hilly or of a light loamy character. These districts occur both in the north and south of this country. In Scotland they are overshadowed by the hill farms, which are sometimes held in connection with lowland farms and give a dual character to the occupation.

It is not in Scotland that we should look for the most typical examples of systematic arable sheep-farming. The prevalence of potato cultivation, the vast area of mountain sheep-walks, the strong character of carse land, and the humid character of the climate, especially on the west side of the country, are unfavourable for the particular kind of farming under consideration. Cattle naturally occupy an important position on the east of Scotland, and although Berwickshire and other border counties are well known in connection with sheep, Cheviot and Lammermoor control the Merse, and sheep-farming often takes the form of a partnership between the hills and the vales.

It is in England that we find the best examples of self-contained and extensive sheep-farming. North Northumberland and the Scotch border counties have much in common, and the districts of Hawick, Alnwick, and Kelso are sheep countries to the backbone. It would be an unpardonable omission to leave out of account the home of the Border-Leicester breed in any review of sheep-farming. The slopes of Cheviot blending with the richer and lower lands, furnish an ideal sheep country. The fells and Millstone Grit soils of Tyneside offer a field for sheep-farming, but too much blended with cattle for our purpose. Omitting Durham, which is not a sheep county, we find in the wolds of Yorkshire (Chalk formation) an excellent example of farming under Leicester sheep on a large scale. The Lincolnshire wolds are continuous, save for the severance effected by the Humber, and run southwards to Burgh and north of the Wash. Parallel with the wolds is the Lincoln Heath, another thorough sheep district resting upon Oolitic limestone. The principal sheep-farming counties are associated with the great Chalk formation, which is continuous south of the Wash, and forms the basis of about fifteen counties.

Norfolk and Suffolk are great sheep-farming counties, and also famous for bullocks. The Chalk formation in Norfolk is comparatively flat, and is the substratum of much light land at Swaffam, Thetford, Lexham, Castle-Acre. This was the site of Lord Walsingham's and of Mr. Colman's famous Southdown flocks, and is not far from Sandringham. Suffolk occupies a high position as a sheep county in connection with the famous Suffolk Downs. A list of the districts in which sheep-farming is a speciality would be in a great measure a list of chalk-land counties. There are, however, some well-known arable sheep lands west of the Chalk formation, such as the Cotswold Hills in Gloucestershire and Oxfordshire; Shropshire, and other midland counties. Our object is to arrive at sheep-farming as a principal occupation, in which all the cropping bends to the flock, in hich cattle are only represented by a cow or two for the house, or where they lead a separate existence on low-lying meadows; where there are wide stretches of country devoid of farm buildings, because they are unnecessary, devoid of fences because the sheep live in folds; where corn is stacked in the open fields, and straw is largely used for the construction of lambing pens; where the sheep-bells tinkle on the downs, and shep-

herds stand resting on their crooks, waited on by their dogs, while great mobs of ewes graze hard by. This is sheep-farming as seen in Wiltshire, Berks, Dorset, Sussex, and other Chalk counties. In former times it was associated with unbroken downs, and the principal winter food was hay. Now it is carried out with the aid of root and fodder crops, but also by open grazing on the sweet and sound natural pasturage peculiar to those districts. The effect of turnip husbandry has been to increase the possible number of ewes on a given area in winter, while the result of green-crop cultivation has been abundance of summer food for ewes and lambs.

A typical sheep farm of the class under consideration is seldom less than 500 or more than 1000 ac. in extent. If it descends into the valley there may be a herd of cows kept, but the high land is entirely devoted to sheep, unless we except the straw yards constructed for dry cows in the winter. In summer no stock but sheep are to be seen, and the cropping is conducted for their maintenance. Corn is a secondary consideration, and on those thin soils owes its luxuriance entirely to the folding of sheep. On such farms one ewe to the acre is a fair measure of their capacity for sheep, and as one lamb to the ewe is thought to be a fair result, it follows that during summer there are practically two sheep to the acre. After the autumn sales, the sheep stock sinks back to the winter level. The ewe tegs reserved for breeding form an extra number beyond the ewe per acre just mentioned.

For the feeding of the large stock maintained during summer, green crops such as winter rye, winter barley, winter oats, trifolium, vetches, and rape are grown, and each of these (except the rape) is folded off and broken up for roots as cleared. The light character of the soil renders this easy, and the folding renders manuring unnecessary, unless in the form of 2 cwt. of superphosphate per acre. The roots are therefore cheaply produced, and the crops are, as a rule, light. The ewe flock is independent of root crops until lambing time, and is kept on stubbles, sainfoin, old seeds, and on the open downs, and may be folded on turnips at night. When the turnip crop fails, the ewes are folded on grass, and receive hay. Hay is indeed a very important food on a breeding farm. As soon as the nights become cold, and frosty rimes fall, the ewes should have hay either once or twice a day. After lambing, roots become more important, both for ewes and lambs, and the latter are allowed to run forward and crop the turnip tops. Lambing is a busy scene on a big sheep farm, when 500 to 1000 ewes are brought into close quarters in the pen, and lambs are falling every day. It takes place in January, and is practically finished in March. Both dams and lambs (couples) are well treated from the first. From weaning to yeaning, the ewes live on the natural produce of the farm, but as soon as parturition is over, cake-feeding begins. First the lamb is fed through the mother, but means are taken to stimulate the flow of milk by the aid of artificial foods. Later, the lambs are supplied with cake, and the amount given to the ewes is gradually diminished until it ceases at shearing time. Meanwhile the lambs receive an increasing quantity, so that the sum total of cake supplied remains the same until the lambs are sold. On very large sheep-farms the consumption of cake may run up to nearly 1 ton a day, but on farms which carry 1000 lambs it may easily reach half a ton a day in the height of the summer. The lambs are weaned in May or June, and are usually given a change of green food daily, and sometimes two or three. The green food consists of vetches, rape, second-crop clover, and early turnips, all of which are available, for 'July keep' is the pride of the lamb-breeder in a southern county. The lambs grow with surprising rapidity, and if the above system is well carried through, the best 100 have been known to fetch 60*s.* each on August 12th. Fifty shillings is not an extraordinary price for a good lot of lambs at Salisbury Fair on July 15th.

Cotswold sheep-farming differs from the above description in several important points. The climate is colder and more humid, and the soil is more tenacious and mixed in character. The Cotswold land varies from 'brashy' limestone to stiff clay of the Bradford, Stonesfield slate, and Fuller's Earth series. It has been described as 'weally' and springy. The Cotswold breed of sheep suits his native tableland admirably, and has never been bettered. Sheep-farming is the main support of the Cotswold farmer, but it is carried on under less easy circumstances than on chalk lands. The green crops are less varied in character and the season is later. Roots are more important than they are in Wiltshire, and the relief of an out-run on open downs is not so available. The flocks are less numerous, and the lambs are run on till they are shearlings. Half-bred sheep form an important feature, and the Oxfords have secured a firm footing on this part of the Thames valley.

Hitherto sheep-farming has been regarded as lamb-breeding rather than as teg-fattening. The truth is that there are several kinds of sheep-farming. First there is ram-breeding, which may be regarded as the highest development of the business. Next there is lamb-breeding, which may be carried on intensively as above indicated, or under less pressure. Thirdly there is the 'flying' stock, which consists in buying draft ewes, and fattening lamb and dam together. It is a system entailing fresh faces, and readily passes into a dealer's business of constant buying and selling. Lastly, there is teg-fattening, which entails buying lambs from the hill farmers at the late summer and autumn fairs, and trucking them to Norfolk or other eastern and western counties for finishing. It is not, however, necessary to enter at length upon the subject of fattening sheep in this connection, because it usually constitutes a part of mixed farming in which bullocks and sheep are both fattened, and the system therefore falls outside sheep-farming in a strict sense.

Equipment of Sheep-farms.—On the class of farms under consideration the buildings are of an elementary type, and often consist of field barns or scattered shelters. The homestead is situated at the bottom of the valley, and com-

prises house, and accommodation for cows, horses, and other descriptions of stock. As already mentioned, the dairy, which term includes the herd, is maintained on the grass land and meadows, which often abut upon a stream. The farm rises gradually to the downs or hills, and the field-barns accommodate work horses and young stock in winter. Threshing takes place in the field, and much of the straw is used in the pens at lambing time. The lambing pen is erected each year where most suitable for food and water. The rotation followed is based on the four-course system, but is modified by catch cropping and by sainfoin. There is nothing to remark upon the implements required, and the number of horses needed is about one pair for every 70 or 80 ac. of arable land. Labour costs from 25*s.* to 27*s.* per acre, and rents are inconsiderable. These large farms owe their productiveness almost entirely to the sheep, and if deprived of their flocks the yield per acre sinks to a low point. On the other hand, under the management indicated, 48 bus. of wheat, 80 bus. of oats, and 50 bus. of barley are not over-estimates, although they are above averages. Under such circumstances, it is not surprising that rents should in some cases be from 5*s.* per acre and upwards to 15*s.*, according to quality of soil and situation. The management is less complicated than on mixed farms, as the shepherd is a responsible and skilful man, who is competent to advise his master as to changes of food, and who attends to all petty ailments, and to the important work of lambing. Each stable is under a competent 'head carter', who has an 'under carter' and boys under him. Where there is a dairy it is either let or placed under the charge of a dairyman, with milkers and helpers under him. The farmer exercises a general control over these heads of departments, but does not constantly interfere with them without due cause. The business is a fairly extensive one, and the farm is generally wide and open. The fields are often 50 ac. in extent, and are divided by the crops rather than by fences.

The capital required for the arable land or the portion which is entirely under sheep may be computed from the sheep stock and teams required. If the dairy is included, the question becomes more complicated; but for our purpose it is better to keep it distinct or to compute it upon the 100 or 150 ac. of permanent pasture which principally supports it. Restricting our figures to the extensive fields which constitute the sheep lands, we arrive at £3 per acre as a sufficient sum for providing one good ewe per acre. Horses and implements will absorb £2 per acre, and labour, as just stated, 25*s.*; seed, 10*s.*; rent, rates, and taxes, 12*s.*; food purchased, according to the system of feeding, may be 10*s.* per acre or a good deal more; manure purchased (superphosphate), not more than 2*s.* 6*d.* per acre over all. Coal, oil, repairs, and incidentals are uncertain, although they are considerable items, as also are trade bills, carriage, and numerous petty outlays. Neither must it be forgotten that in taking over a large sheep-farm in October the incomer must pay for all the tillages on the growing root crop, and any ploughing, dung-carting, and tillage performed by his predecessor. He will also pay compensation for cake fed, and other unexhausted improvements left by the waygoing tenant. If the farm has been well managed, and the system followed is to continue, a large sum will fall to the outgoing tenant (see CAPITAL). Thus tillages and compensation may easily reach 30*s.* per acre. We in this way obtain a general, although far from an exact, idea as to the capital required in order to take immediate possession of such a farm. According to the above estimate they may be summarized as follows:—

	£	s.	d.	
Sheep stock	3	0	0	per acre.
Horses and implements ...	2	0	0	
Seed	0	10	0	
Rent, rates, and taxes ...	0	12	0	
Food purchased	0	10	0	
Manure purchased	0	2	6	
Payments to outgoing tenant	1	10	0	
	8	4	6	per acre.

The incidental expenses and trade bills, such as blacksmith, &c., are omitted, as well as household furniture and money in hand. All that the above schedule shows is, that the items set forth must be met, and should be provided for before undertaking to enter upon the business. It therefore seems that £10 per acre ought to be forthcoming, and it further seems probable that the same amount per acre would be required if in addition to the sheep land the incomer takes over the dairy on the grass portion of the holding. Nearer than this we cannot pretend to come, without attempting too much.

Return.—Again, confining ourselves to the sheep land, the yield per ewe where 10*s.* per acre is spent on purchased food might be 40*s.* per acre, allowing a fair fall of lambs, and wool at 9*d.* per lb. This is arrived at as follows:—

1 lamb	36*s.*	(average)
1 fleece	4*s.*	
	40*s.*	(allowing for casualties).

The corn crops might average £7 per acre, reckoning something for straw for the dairy or for sale, and if two-fifths of the total arable land is in corn (200 ac. in 500) the value per acre will be £2, 16*s.* per acre over all. This, added to 40*s.* per acre for sheep, amounts to £4, 16*s.* per acre, and with luck and good management might be £5 per acre. This is not a bad gross return for land rented at 10*s.* per acre. As to profits, the materials are not to hand, and it is extremely difficult to make reliable schedules as to costs or returns. [J. Wr.]

SUBURBAN FARMING

The proximity of large towns modifies the practice of farmers in several directions. It naturally induces a desire to sell produce and bring back town manure for the land. It may even cause the abandonment of ordinary cultivation for systematic market gardening. It is our object to give an idea of farming as modified by the near neighbourhood of markets, and to furnish examples from actual cases. The con-

ditions are in many respects different from those of rural districts, in which labour is comparatively cheap, straw abundant, and produce chiefly exists in the form of corn, cattle, and sheep.

In suburban farms the arrangement of buildings is naturally contrived with a view to cow-keeping, for milk must be one of the chief products in such situations. The advantages to the milk seller are of a substantial character, because in the first place the morning and afternoon milk can be delivered what is termed 'warm', *i.e.* fresh, and in the best condition for use at breakfast and tea. The price given is higher than for milk from a distance, and railway carriage is saved. If sufficiently near the town or its suburbs a 'milk-walk' probably exists appropriated to the farm, in which milk is sold at retail prices. It is true that rents are higher on this account, but when milk can be so disposed of, the gross produce from each cow is much greater than in remote localities.

One of the most experienced suburban farmers ever known to the author informed him that each cow produced £5 per annum per ¼*d.* per pint of milk produced, or in other words that 1*d.* per pint meant £20 per cow. The animals were liberally fed, and were of the best type of dairy Shorthorns. As the retail price of milk is generally from 2*d.* to 2½*d.* per pint, it is clear that according to this scale a cow may realize from £40 to £50 per annum. In the case cited, the custom was to buy newly calved cows and feed them on a dietary calculated to stimulate the flow of milk and fatten the animal simultaneously. The cows were not bred from, but as soon as the yield of milk sunk below a certain point, they were at once disposed of to the butcher. By this means the yield was kept at a maximum; there were no dry cows or young stock, and the milk register was kept up to a high level. The assumption of £5 per cow per ¼*d.* a pint appears indeed to be below what might be realized, supposing the milk yield to exceed 800 gals. per cow per annum, which at 2*d.* per pint would be represented by £53, 6*s.* 8*d.* With the prospect of such returns, even if heavily discounted by bad debts, disease, and losses, it is difficult to see how any better method of procedure could be devised. In order to obtain such results the buildings should be designed with a view to the comfort, health, and cleanliness of the cows, and also to the economy of litter. The lairs should be level and smooth, and laid down with concrete, glazed bricks, or other non-porous material capable of being washed down daily. Litter is sparingly used, and may consist of moss, or cut straw, sprinkled thinly over the floors. In some cases litter is entirely dispensed with, the cows lying on thick sheets of rubber securely attached to the floor. This prevents bruised and swollen knees. A source of water is highly desirable in order to wash down the lairs, and the liquid manure is conveyed by open drains to a tank. Here is another feature of suburban farming which is worthy of notice, for in rural districts liquid manure is not, on the whole, thought desirable, as covered yards well supplied with straw render such tanks unnecessary. In the present day, when legal enactments are to be expected with a view to regulating our milk supply, it is evident that every care should be taken to preserve health and cleanliness among the cows. With the sale of new milk the keeping of pigs becomes undesirable and is not extensively attempted, but poultry may well become an additional source of income. Fresh-laid eggs and early chickens always sell well, and the suburban farmer enjoys an excellent opportunity for supplying both.

The cropping of the farm will entail a small area of corn and a large amount of hay. It is noticeable that even in the neighbourhood of the metropolis a great deal of land lies in permanent pasture, and this has often given rise to remark. Middlesex haymaking has always been famous, and the near neighbourhood of the London market has stimulated the production of the best quality of this product. Milk and hay go well together, and grass land is the natural foundation of both. We, however, turn to a less natural system, in which the land is cropped, and such roots as mangel-wurzel and turnips, or such plants as kohlrabi, cabbages, lucerne, clover, vetches, &c., are grown for summer and winter feeding. A proportion of grass land is desirable for summer grazing and providing hay, as well as for affording exercise to the cows.

The amount of artificial food consumed is considerable, and town manure is also brought back in empty carts and wagons. This traffic induces the sale of roots, fodder, and straw to the town, for there is no reason why these crops should be entirely consumed at home. There can be no objection to the sale of mangel-wurzel, turnips, and swedes, as well as straw, when manure is imported to supply their place, and the prices for these commodities are very remunerative. It is, in fact, an excellent arrangement, and is in full force around London, Edinburgh, and other large towns. Even in the remote country, 15*s.* per ton is easily obtained for mangel in the spring, and £1 per ton is not an unusual price in towns. The suburban farmer lays himself out for supplying carrots and roots to horse-keepers, and does all in his power to economize hay and straw. This leads to chaff-cutting and pulping, the advantages of which are peculiarly evident when the products concerned all command high prices. The four-course rotation with a mixed stock of cattle and sheep would evidently be inappropriate in a situation such as we have before us. There is every opportunity of keeping up the fertility of the land, both by artificial foods and the importation of town dung, and the course of cropping is dictated by the demands for special forms of agricultural produce. Those who have witnessed the distribution of bundles of green vetches and other kinds of fodder to suburban stables, at an appreciable price per bunch, must have been struck by the high value per acre of the crops supplying them. The suburban farmer keeps good horses, and turns them out well in his vans and wagons. He is not a market gardener, although he may lean in this direction and cultivate strawberries, celery, rhubarb, and

all manner of fruits and vegetables. In proportion as his system becomes complicated, more capital is required and more labour expended. Both far eclipse the requirements of rural farms; but, as stated at the outset, our object is not a description of fruit and vegetable cultivation, but a simple statement as to the peculiar characters of suburban farming in contrast to the agriculture of the shires and counties generally. [J. WR.]

Farm Labourers. See LABOURERS.

Farm Management — The management of farms depends in large measure on the point of view from which the farmer looks at his work. If he farms simply and solely to make money, he will study economy at every turn, and carefully calculate all the chances before making any investment or undertaking a new venture. The man who farms to make a comfortable home for himself and his family will allow something of sentiment to enter into his calculations, asking not only will such and such an operation pay, but also will it tend to greater comfort and convenience. Another, who treats farming as a hobby or pastime, may not care whether his holding shows a profit or not. He wishes to have everything about him of the neatest and tidiest description. His horses, if not the best workers, will be full of the best blood. His cows may not be the best of milkers, but they will be beautiful animals to look at. His sheep may not be noted as mutton producers, but they will have fashionable coats and stylish heads. It is possible to find a farmer bent on moneymaking who values the comforts of his home, and studies to have beauty and symmetry of form prominent among all his animals, but such a type is rare.

Although it is claimed that British farmers are as a class among the most intelligent of men, it has to be admitted that farming on the whole in this country is not a profitable occupation for a man of energy and enterprise. The vast majority of agriculturists, even at the reduced rents which have been arrived at, by a gradual process during the last quarter of a century, do no more than make ends meet. Some succeed in securing a competency, a few do even better; but against these have to be set the considerable number who lose their capital in addition to years of their lives. And if farmers are not doing more than holding their own, it is not because the landlords are making fortunes at their expense. Without doubt during the last twenty or twenty-five years the capital value of farming land in this country has fallen very considerably, and the yearly income of all proprietors has shrunk, in some cases almost to the vanishing point.

In general farm management the two main objects are: (1) to grow or rear farm produce, and (2) to dispose of such produce to the best advantage. It is not only desirable to know whether a certain holding can produce a commodity which will be marketable, but whether it can produce that article at the right time. It is said that in our large centres of population almost anything can be got at any time. This is probably true—but if so, very different prices will be asked at different times for the various commodities. Wherever it is possible, the farmer must endeavour to have his goods ready for sale when there is the best demand for them. Having produced goods at the right time, the second object of the farmer is to secure the best price for them. This involves the question of marketing. On this subject every farmer has his own views. One prefers to sell direct to the consumer, another to the middleman. One does the actual selling himself, another employs an agent, dealer, or auctioneer to do the selling for him. Each method has its advantages. By selling direct to the consumer the middleman's profit may be saved, or divided between seller and buyer; but as the middleman has presumably a number of customers, he may be able to give a better price because the article he is buying is very suitable to one or other of his clients. By selling his own stock or produce the farmer may save the auctioneer's commission; but at an auction sale a variety of buyers see the stock, and a spirit of rivalry sometimes rises and enhanced prices result—prices which cannot be approached, far less surpassed, in a private transaction. Whatever method of marketing a farmer adopts, it is wise to follow the same custom year after year. In some seasons the man who sells privately will do best, in others the man who sends all to the marts, but no one can tell who will be right and who will be wrong. When prices are falling, generally speaking, the man who sells privately is most fortunate, but when prices are tending upwards the chances are in favour of the one who sends his goods to a public sale; but in a series of years the most satisfactory results are attained by following a consistent plan.

If the practical side of farm management is to produce what is wanted at the right time, and sell the goods in the best way at the best market, the economic side is to make the receipts surpass the expenses. The problem is to cheapen the process of production without diminishing the value of the goods produced. This is the problem of problems to the farmer. He has many difficulties to face. His operations are slow, for nature, his great partner in all his schemes, is never in a hurry. For the most part, once a year only has a certain thing to be done, and experiments take a long time to mature. Besides, more than is the case with most businesses, that of the farmer is subject to influences, such as the weather, over which he has no control. And really, in the presence of the great forces of nature and natural laws, the farmer is bound to feel himself many a time very helpless. All he can do at the best is, by diligence and watchfulness, to give nature a chance. He cannot influence the rainfall or the sunshine, so essential to the growth of the young plant, but he can pull the weed, and so let the sun when it shines, and the rain when it falls, do their best.

The matter of servants and servants' wages is intimately connected with the economic side of farm management. Farmers are being more and more driven to the use of labour-saving implements, and the intelligent agriculturist will

be always ready to select such as are most suited to his holding. Every year some new farm machinery is put on the market, and to many the implement sections of the great annual shows are of the deepest interest, and to not a few they afford a liberal education.

Many farmers have found it most profitable to specialize. Generally speaking, it is the man who has selected one line and devoted himself to that who has done best, although to this, as to most rules, there are exceptions. Among arable farmers some have done remarkably well by potato growing of late years, and from suitable soils—such as the red soil of the Lothians—very handsome returns have been secured. Among stockmen, the breeders of pure-bred Shorthorns have had a successful time, mainly owing to the active demand which has been experienced for good sires for the Argentine. A number of moneyed men having of late interested themselves in the Blackfaced breed of sheep, those who have had the fashionable type of ram to sell at Lanark or Perth have been well recompensed for their foresight and enterprise. But in every department, even in the worst time and at the worst market, there is always a demand for the best, and he who has the best to sell gets his reward.

Farming is, or ought to be, a *business*. Many seem to forget this. Accounts are often carelessly kept, if kept at all. No note is taken of the feedingstuffs bought or the manures applied, and consequently no definite or intelligent opinion can be formed as to the cost of production. There is no doubt the want of business habits is the cause of many a farmer's lack of success from a moneymaking point of view. As time goes on, this state of matters is improving. Most farmers realize that their sons would be the better of educative advantages they never had, and in considerable numbers the farmers of the future are attending one or other of the agricultural colleges of the country. Nothing could be a greater help to young agriculturists. They are not only made acquainted with the latest theories and most approved methods, but they have opportunities of seeing farming done on thorough business lines, and bookkeeping suitable to the farm is taught.

The business side of farm management is of special importance in Britain, where money has to be found for rents, and where consequently a great proportion of the commodities produced are produced for sale. In France and certain other Continental countries the peasant farmers living on their own land live off it, that is, they consume what they grow, and *money* does not play such an important part as on this side of the Channel. The British farmer very often buys what he might have been expected to produce. It is quite common, for example, for a dairy farmer who devotes his energies to cheesemaking to buy the butter he needs for his household, and the man with hundreds or thousands of sheep on his hills will buy every leg of mutton used on his table from the neighbouring butcher. Consequently money and commercial transactions come in on all hands, and a business training is becoming more and more needful for the farmer as the years go on.

With all their lack of business habits, farmers are, as a class, of a commercial turn of mind, and the old custom of attending the weekly market when there is little or no need to do so, although dying out, is dying hard. We have heard it suggested that the bartering at the fair is the one bright spot in the otherwise monotonous existence of the farmer. Be that as it may, there is much less needless attendance at markets than there used to be, and consequently more attention to the farm. This change of habit—going less to public places—leads farmers to employ auctioneers more for the sale of their stock; or it may be the other way, because auctioneers exist to sell stock, farmers have less occasion to go to the market, and consequently the custom is disappearing.

In certain districts, and within limits, there is some co-operation among farmers; but they have, generally speaking, been slow to take advantage of the benefits either of combination or co-operation.

The details of farm management are dealt with in the articles on the various classes of stock—sheep, cattle, horses, &c.; on the different kinds of farms—dairy, arable, mixed, &c.; and on the farming operations of the year, such as haymaking, harvesting, &c., to which articles the reader is referred. Generally speaking, success in farming depends on personal supervision and management. If the farmer brings attention and business aptitude to his work, even in difficult times and trying situations he can make a living, possibly more, but everything depends on his personal energy. Times have changed, and much has come and gone, since the old couplet was written, but it is still true:

> 'He that would thrive must rise at five;
> He that has thriven may lie till seven'.

[W. B.]

Farm Steward. See BAILIFF; and AGENT, LAND.

Farmyard.—The place of the kind so dear to the artist is now almost a thing of the past. A farmyard such as Morland could depict with so much effect is now only rarely to be met with. A yard of this description was cattle court, pig run, and dunghill in one. Nowadays there is universally differentiation of a sort. The court proper is open, and gives access to stable, barn, and the buildings generally, and fold yard or cattle court and dungstead are usually apart (see art. BUILDINGS, FARM, and its accompanying illustrations). At some classes of homesteads the dungstead occupies the whole of the space enclosed by the three sides of the square, the common arrangement of the buildings in these instances. Access to the buildings is given from outside the square as well as from within. Where it happens to be practicable to roof the yard, live stock have quite comfortable quarters therein, and in that way the accommodation of the steading can sometimes be added to at small expense. But hardly two farmyards are quite alike. In whatever manner arranged, however, it is nearly always possible to make the most of the farmyard and have it good of its kind. If

it is a yard proper—that is, an open space to act as service ground for the buildings as a whole—unless it be firm under foot, and at same time drained in such a way that water cannot lie thereon, it will be in puddles nearly all the year round. On the other hand, if it be mostly a cattle court, unless arranged on the principles referred to under head of DUNGSTEAD it will at all times be untidy, and wasteful too. These maxims hold good, of course, in cases where mixed arrangements are observed.

[R. H.]

Farmyard Manure.—Farmyard manure is the name generally applied to the manure obtained from the feeding of cattle at the homestead, and consists of the solid and liquid excreta of the animals that are being fed, together with the litter used for bedding and for retaining the droppings of the cattle. Dung is an equivalent term. The stock used for making the manure are, more generally, fattening bullocks or milking cows, but may include also horses and pigs. Sheep are almost invariably penned out on the fields or run over grass land. The material most commonly used for litter is straw, of which wheat straw is the favourite kind, oat straw being more often used for feeding, while barley straw is rough and considered 'itchy' for stock. In the absence of straw, or of a sufficiency of it, other materials, such as peat-moss litter, rough or spoiled hay, bracken, spent tan, sawdust, and other waste materials, are employed; and in the case of cattle fed in boxes, earth may be used to supplement the supply of litter, and to assist in retaining the urine and so preventing loss.

Of the different materials employed for litter, peat moss is the best absorbent; it can be kept down longer under the cattle than can straw, and it also supplies the richest manure in the end, the peat moss itself having a higher manurial value than is possessed by either straw or sawdust. There is, however, a certain prejudice in the minds of some against the use of peat moss as litter, especially for horses, but for this there is no real warrant, though no doubt peat moss takes longer than straw to work into the land and to decompose. Further, peat-moss litter manure, as generally removed from stables in towns, is not as thoroughly saturated as it would be on a farm, owing to its rapid and frequent removal. Whether it will 'pay' the farmer to employ peat moss for litter must depend entirely upon whether he has a sufficiency of straw on his holding, and whether he has a good sale for straw or not. If there be no ready sale for straw it would naturally be the most economical plan to feed the straw and use it for litter at home; while, if there be a good outlet for selling straw, it might pay him to purchase peat moss or use other substitutes for straw as bedding. Sawdust is a good absorbent of urine, but its own manurial value is much inferior to that of either peat moss or straw, and it would only pay to use sawdust as litter if a regular supply of it were available for the mere cost of short cartage.

The excrements of cattle consist of two portions, the solid and the liquid. The former, which represents the less digested parts of the food used, and those which, consequently, have undergone the least change, comprise the bulk of the phosphoric acid, lime, magnesia, and silica derived from the foods, while it contains, on the other hand, but little nitrogen, and that not in a readily available form. The liquid portion, *per contra*, contains the bulk of the alkaline salts and of the nitrogenous organic bodies which are capable, on decomposition, of yielding ammonia readily. Potash and nitrogen are thus the principal constituents of the urine, while phosphoric acid and lime are contained mostly in the solid excrements.

The quantity and quality of the excrements, solid and liquid, will vary according to the kind of animal by which they are produced, the age of the animals, and the foods which are given to them. The excrements of pigs and cattle are more watery than those of horses or sheep. Hence the stable manure from horses ferments more readily and is known as 'hot', whereas that from oxen, cows, and pigs ferments more slowly and is termed 'cold'. This is a fact well known to, and made use of by, market-gardeners in particular. Again, a young growing animal will use up more of the constituents of its food in putting on bodily increase, and so will pass less into the excreta than will a fattening animal; and similarly a milking cow, which is sending off the farm nitrogen and phosphoric acid in the shape of milk, will give poorer excreta than will a fattening bullock. In regard to the food consumed, there will further be considerable differences whether a merely maintenance diet be given, as for a horse at rest, or whether a full diet for a fattening animal be provided. Speaking generally, there is the least amount of nitrogen and ash constituents found in the excrements of a young growing animal, then of a milking cow, next of a fattening pig, more in those of a fattening bullock, and most in the case of a horse. The urine of a milking cow or fattening pig has proportionately less nitrogen than that of a fattening bullock.

In respect of the foods consumed by different classes of stock, a young growing animal, like a calf, for example, will utilize about 70 per cent of the nitrogen of its food, and pass only about 30 per cent into the excreta; a milking cow will use up 25 per cent and give 75 per cent to the manure; a fattening pig passes 85 per cent of the nitrogen into the excreta; while with a fattening bullock or a horse 95 per cent or more of the nitrogen is voided in the manure. The quantity of urine produced is largely determined by the amount of water in the foods given; thus the free use of roots will tend to increase the quantity of urine. The urine of sheep and horses is, similarly, more concentrated than that of cattle and pigs. The amount of nitrogen in the urine is with all fattening animals quite three times that contained in the solid excrements. When the food given is nitrogenous in character and easy of digestion, the nitrogen in the urine will proportionately increase.

From the above considerations it will be seen how very necessary it is to safeguard that the

valuable nitrogen of the urine be retained as far as possible in the farmyard manure. This leads to the next consideration, the methods of making and storing farmyard manure, and the losses incurred thereby.

Farmyard manure may be made either in regular stalls or feeding boxes entirely under cover, or else in yards, either wholly or partly covered in, or entirely open. In all cases, except possibly that of milking cows brought in just for milking, litter will be used, straw being, as we have seen, the most common. According to these conditions, as also to those just considered (viz. the kind and age of stock, the food given, and the litter employed), so will the farmyard manure ultimately produced vary in quality. When one compares, for instance, the well-trodden-down dung taken from a feeding pit or closed box, or even that from a covered yard, with that removed from an open yard, where the manure has been exposed to rain and weather, it needs little discrimination to know which must be the better. Or again, when one compares an open heap in the field, from which dark streams of humous matter flow out on every occasion of a fall of rain, with one which has been closely packed and covered with earth, and so protected from wind and weather, there can be little doubt as to which will give the better crop. Yet it remains a fact that farmers take far too little care on these points, and too often, to quote the words of the late Wren Hoskyns, the farmer is found carting out the 'treasures of the farmyard whose spirit is exhaled before the body is buried'. At a time when cattle feeding is far from a profitable business, and when feedingstuffs are expensive, it must come home to one as most unreasonable not to take steps to preserve the farmyard manure to best advantage, especially when one remembers that no less than 95 per cent of the entire nitrogen of the food given to fattening animals passes into the manure, and is liable to undergo loss by decomposition. In too many cases manure is made in yards quite open; the rain comes and washes out the soluble potash salts and nitrogenous matters, and these find their way into the drains and are lost, so that when the yard is ultimately cleared out, it is little but the straw or 'dead body' that is carted out to the fields. In some cases, it is true, provision is made for the collection of the urine and drainings in tanks below the ground level, and from these the liquid manure is either (as is a good plan) pumped back over the litter in the yard, or is carted out and poured over grass land. But even this practice by no means holds good universally, and far too much is left to the chance of weather.

Without question, the best farmyard manure is that made in feeding boxes or pits sunk below the floor level, a fresh sprinkling of litter being put in every day, and the manure being left to be trodden down by the animals, and to gradually accumulate, without being removed, during the whole time of feeding. In this way a solid mass of rich manure is formed, the loss from which is less than from any other method of making, the health of the animals is in no way affected, and at the conclusion the manure can be dug out and put in a heap or spread on the land. Of this kind are the feeding boxes at the Woburn experimental farm of the Royal Agricultural Society of England, and experiments with the manure taken from these have repeatedly shown its superiority to that made in open yards. The next best way is to make manure in covered yards, it being thus, if not so well trodden down as in feeding pits, at least consolidated to some extent, and also quite protected from the weather. After this comes feeding in stalls, in which case the manure is less thoroughly 'made' and is more frequently removed to the heap, its 'steaming' appearance showing that changes are going on rapidly in it and to a large extent unchecked, so that loss must occur. Inferior, however, to any of these methods of preparing manure is that of having it made in an open yard exposed to storm and rain, and where much of the 'goodness' will find its way into the drains and be lost.

When the manure has been made, one way or another, it can be carted out to the fields on which it is intended to be used, and either spread directly and ploughed in, or else put in a single large heap. The former is the better plan; but in this, as in other matters of the farm, theoretical and even scientific considerations have often to give way to the exigencies of practice. A farmer has often to cart out his dung, not when he would *like to*, but when he *can*, and so it is with the spreading and ploughing in of manure. Experiments have shown that dung spread out at once in a thin layer over the ground will lose comparatively little. If, however, as is sometimes done, the dung be left in small heaps scattered over the field it may suffer considerable loss, the outer portions of the heaps becoming alternately sodden and dried up, while the more soluble portions, instead of being distributed over the whole field, are concentrated just where the heap lay. The appearance of a spot where a manure heap has stood is only too well known, and over-luxuriance of the crop at the particular spot is the sure mark of this. If therefore, the dung cannot be at once spread and ploughed in, it must be kept in a single large heap in the field or at the homestead, and be well pressed down and consolidated. The best way to preserve it against loss is to throw earth over it, and, as the heap settles down, to flatten the sides down and cover with more earth. If this be done, it will be found that little or no drainage escapes. Various suggestions have been made as to the use of materials for absorbing ammonia and so preventing loss. Gypsum is one such material which has been frequently advocated; superphosphate and kainit are others, while sprinkling the heap with dilute oil of vitriol (sulphuric acid) has also been tried. But experiments have shown that none of these are thoroughly effectual or remunerative, and the plan before mentioned, of covering with earth, has been found to be the best and the most easily adopted.

The changes which farmyard manure undergoes during its making and storage are those

which take place in (*a*) the urine, (*b*) the solid excreta of the animals, (*c*) the material used for litter. The urine we have seen to contain, as fertilizing constituents, mainly soluble phosphates, potash salts, and soluble nitrogenous matters, among which are urea and uric acid. These constituents are in a form practically ready for the nutrition of plants, or requiring but little change to make them so. The phosphates and potash salts undergo no change, but the soluble nitrogenous matters are soon attacked by organisms which very readily convert the urea into carbonate of ammonia, this in turn being broken up into ammonia and carbonic acid if freely exposed to the air. The pungent smell arising from a manure heap, or noticeable in a stable, is due to this escape of ammonia into the atmosphere. It forms the principal source of loss in the making of farmyard manure, and its conservation is thus of the highest importance.

A yet further loss of ammonia is that which takes place by the process known as 'denitrification', one brought about by another set of organisms which have the power of resolving ammonia into nitrogen gas and water. This action goes on most rapidly if readily oxidizable substances such as soluble carbohydrates are present, and when oxidation can go on freely, as, for instance, when the manure is in a loose and open condition.

Manure allowed to lie loosely packed, and thus more open to the air, will lose ammonia much more readily than if closely packed or kept trodden down or covered over; heating is induced, bacterial changes go on more rapidly, evaporation ensues, and the loss in fertilizing value is intensified.

In the solid excrements, on the other hand, the fertilizing constituents are those derived from the portions of the food which have resisted the action of the digestive ferments of the animal, and they are thus less liable to decomposition. Indeed, they have to go through several processes of change before they become available for the plant's use. They consist mainly of the insoluble phosphates, the lime, and the insoluble nitrogenous organic matters derived from the food given. The phosphates and lime are not subject to further changes or loss, but the nitrogenous matters, as in the case of the urine, are acted on by bacteria, though much less readily than are the nitrogenous matters of urine. Eventually, however, these bodies are broken down into simpler bodies, to the ultimate form of ammonia, frequently (and especially in the case of the nitrogenous matters of the straw) through the intermediate stages of the formation of amino-acids and amides. Even after ammonia has been formed there would appear to be an action of the opposite character, the bacteria seeming to have the power of converting the soluble ammonium compounds back again into insoluble bodies, so that the longer the dung be kept the more are the ammonium compounds likely to be found in an insoluble form.

Similarly, the constituents of the straw or other material used for litter will undergo changes, not only through the nitrogenous matters being acted on by bacteria, as in the case of the solid excreta, but also by the action of another set of organisms which attack the cellulose and other carbonaceous matters of the straw. This latter change is seen in the conversion of the straw into a dark-brown mass, or 'humus' as it is termed. These organisms are capable of working in the absence of oxygen, and they break up the carbohydrates, forming carbonic dioxide (CO_2), marsh gas (CH_4), hydrogen and other gases, various acids, and the brown matter known generally as 'humus'. The acids formed are neutralized by the liquid part of the manure, and in this the humus is partly dissolved, and constitutes the dark-brown liquid that may be seen issuing from farmyard manure heaps. This liquid contains salts of humic, ulmic, and other acids. As the straw, &c., is kept longer in the heap, so it tends more and more to break down, and to pass from the stage of 'long' straw to 'short', and to become more rotten. If the heap be kept well pressed down and air be excluded, there will be no great loss of valuable nitrogenous matters, and the manure becomes richer and richer as it gets older, and this mainly through the loss of the carbonaceous matters.

Yet one other source of loss must be mentioned, that produced by fungi, which develop when manure is left loose and allowed to get too dry. The heap assumes a white mouldy appearance, and further loss is entailed.

The losses which farmyard manure undergoes in its making and storing will, accordingly, depend upon a great variety of circumstances, and it is impossible to say with any exactitude what these are likely to be. It has, however, been established by repeated feeding experiments that no loss of the nitrogen of the food supplied takes place through what is given off by the animal in the gaseous form, but that if the amount used up by the animal in body increase (which may, as the result of experiments, be put at 5 per cent) be deducted, the rest of the nitrogen should be found in the solid and liquid excrements. It has remained, therefore, to carry out experiments in which the manure has been made and conserved under the best-known conditions, and to find out what actual loss is incurred by the time the manure is put out in the field. Such experiments are on record alike in Germany, France, and our own country, and they all agree very fairly in showing that the loss in making farmyard manure amounts to about 15 per cent of the total nitrogen of the food, in addition to what is retained by the animal, while subsequent storage and keeping in a heap will raise the loss to about 35 per cent.

In Germany the most complete set of experiments are those conducted by Maercker and Schneidewind in 1896 and 1897, in France by Muntz and Girard, whilst in England a very comprehensive series was carried out at the Woburn experimental farm of the Royal Agricultural Society of England over the three years 1899, 1900, 1901, and supplies information as to the separate losses during the making and the storing. Other experiments, by Wood at Cambridge and Russell and Goodwin at Wye

College, have given results in general confirmation of the foregoing. In Maercker and Schneidewind's experiments the loss of nitrogen of the food in the making of manure was 13 per cent under the best conditions (in a deep feeding box), and rose to 36 per cent on storing in a heap. Further, it was found that the losses fell mainly on the active nitrogen in the urine, and that some of this had been transformed to the insoluble form. In Muntz and Girard's experiments, where the manure was removed every day, the loss went up to 30 to 35 per cent of the nitrogen in the food. In the Woburn experiments the losses—taken over the three years—were, after deducting for live-weight increase, 15 per cent of the total nitrogen of the food, in the making, and 34 per cent (or a further 19 per cent) after storing and by the time the manure came to be put on the land. It is thus clearly established that even when made and kept under the best possible conditions, farmyard manure will lose in the making about 15 per cent of the total nitrogen of the food, independently of that utilized in body increase, and another 20 per cent in the storing. Hence, after allowing for 5 to 6 per cent used in body increase, one may very fairly say that under the ordinary conditions of the farm there is not above 50 per cent of the total nitrogen of the food recovered in the dung that actually goes on to the land, this being, it may be mentioned, the figure which Lawes and Gilbert allowed for in the practical working of their Tables of the Unexhausted Manurial Value of Foods consumed on the Farm. Further, the more concentrated be the food given, the greater proportionally will be the loss, this falling most on the readily digested portions of the food, which go so largely to produce the urine and the soluble nitrogenous bodies contained in it, and which are so liable to decomposition and loss.

As regards the actual loss of weight experienced in the storing of dung, this, again, will depend largely upon the conditions of the case, and the length of time of keeping. In experiments made at the Woburn experimental farm, where the dung was made in feeding pits during the winter, then removed and stored in heaps covered with earth, the loss has been found to range from 20 per cent of the total when the dung was kept for three months (November to end of January), to 25 per cent when kept for four and a half months (November to middle of March), and 35 to 40 per cent when kept for six months or more. In a trial made by a practical farmer in Yorkshire, where the manure was carted out and merely put in a large heap, not covered over, it was found that 507 cartloads led out on August 28 gave, in the middle of November, 312 loads only when spread out in the field, or a total loss in weight of 38½ per cent.

Having considered the changes which farmyard manure undergoes, and the losses experienced before it is put out on the land, we may now pass to the consideration of its quality when it comes to be actually used. As has been explained, it is impossible to give any precise statement as to the composition of farmyard manure, influenced as the latter must be very materially by the variable conditions of its production and storage. It may, however, be said generally that farmyard manure will have from 65 to 80 per cent of water, from ·45 to ·65 per cent of nitrogen, from ·4 to ·8 per cent of potash, and from ·2 to ·5 per cent of phosphoric acid, and that 1 ton of farmyard manure will supply from 10 to 15 lb. of nitrogen, 9 to 18 lb. of potash, and 4 to 9 lb. of phosphoric acid. To go somewhat further into details, the following is taken from a very complete analysis made by the late Dr. Augustus Voelcker, of well-made farmyard manure:—

Water ...	75·42
[1] Organic matter	16·52
Oxide of iron and alumina	·36
Lime	2·28
Magnesia	·14
Potash	·48
Soda	·08
[2] Phosphoric acid	·44
Sulphuric acid	·12
Chlorine	·02
Carbonic acid, &c.	1·38
Silica ...	2·76
	100·00
[1] Containing nitrogen	·59
Equal to ammonia ...	·72
[2] Equal to phosphate of lime	·96

With the increased use of cake in feeding, the probability is that cake-fed manure frequently gives results higher in nitrogen than the above. Analyses of farmyard manure made at Rothamsted in the years 1904, 1905, 1906, and 1907, in which that made with roots and hay only was compared with cake-fed manure, showed, for the total nitrogen contents, figures which range from ·46 to ·58 per cent when roots and hay only were fed, while in that from cake-feeding the nitrogen varied from ·69 to ·81 per cent, the averages being ·523 per cent for roots and hay, and ·73 per cent for cake-feeding. Cake-fed manure made at the Woburn experimental farm in the winter of 1902-3—the food given having consisted of decorticated cotton cake, maize meal, hay chaff, and turnips, with wheat straw as litter—gave, when applied to the land in February and March, 1903, respectively:—

	Feb. 13 per cent.	March 19. per cent.
Moisture ...	69·030	71·640
Total nitrogen ...	·771	·754
Nitrogen as ammonia	·134	·078

A closer examination of the Rothamsted results shows that the extra nitrogen in the cake-fed dung consisted mainly of that in the readily available forms of ammonia, urea, and amino compounds. Cake-fed manure, therefore, if put on shortly after being made, may be expected to give a better return in crop yield during the first year of its application than manure made without cake, and crop results at Rothamsted obtained from the use of the above kinds of manure seem to bear this out.

It has been pointed out already that well-rotted 'short' manure is much richer than freshly-made 'long' manure. The following figures show this:—

	Fresh (long-straw) manure.	Well-rotted manure.	Old (short-straw) manure.
	per cent.	per cent.	per cent.
Nitrogen ...	·544	·597	·80
Phosphoric acid	·318	·454	·627
Potash	·673	·491	·674

In the vicinity of towns, or where railway or canal-boat charges are not prohibitive, it is possible to purchase stable manure or even to obtain it for the carting. This is largely used by market-gardeners. Such manure is, of course, of variable composition, the variety in this respect being due largely to the nature of the materials used for litter. The following analyses by Dr. Bernard Dyer, of London Stable manure, both fresh and after storage, will be found of interest:—

MIXED PEAT AND STRAW MANURE.

	Fresh.		After storage (8–9 months).		
	1. per cent.	2. per cent.	1. per cent.	2. per cent.	3. per cent.
Water	76·1	62·0	53·8	61·9	52·9
Organic matter ...	19·3	26·4	17·5	22·0	23·0
Nitrogen (soluble) ...	0·08	0·08	0·06	0·08	0·10
,, (insoluble) ...	0·46	0·62	0·58	0·68	0·79
Phosphoric acid ...	0·33	0·45	0·49	0·56	0·66
Potash	0·45	0·58	0·58	0·65	0·80

A noticeable feature in these analyses is the small amount of nitrogen that is in a soluble condition; this is due, no doubt, to the frequency with which the stables in towns are cleaned out, and the many turnings over to which the manure is subjected, and the consequent open and loose condition in which it is kept.

Farmyard manure is what is termed a 'general manure', by which is meant that it supplies practically all the elements of fertility which crops require. A reference to the analysis given on p. 166 will show that it contains alike organic matter, nitrogen, phosphoric acid, potash, lime, and other necessary ingredients of plant life. Besides this, these do not exist in one single form, as is often the case with artificial manures, but the constituents are in various forms, and of greater and less solubility, so that one after the other becomes available for the use of a growing crop. As we have seen, nitrogen, for instance, occurs not only in the form of ready-formed ammonia, or as salts of ammonia, but in many different forms of nitrogenous organic bodies of varying degrees of solubility and availability; similarly is this the case with the phosphates and other mineral bodies contained. It is sometimes called a 'perfect' manure; but though, doubtless, if sufficient of it be available, crops may do without any other application, yet it contains too little phosphoric acid to quite merit this description, and hence, for root crops in particular, it is advisable to supplement the supply of farmyard manure with readily available phosphate, as in the form of superphosphate. The real difficulty with farmyard manure is to get enough of it; but, where obtainable, it serves a special purpose, that of supplying 'substance' to the soil, which it is not possible to do with artificial manures. At the same time it is quite feasible, as has been shown in the continuous corn-growing system of Mr. Prout at Sawbridgeworth, Herts, which has now gone on for over forty-five years (see art. FARMING, SYSTEMS OF), to dispense entirely with farmyard manure on certain soils, and to rely upon artificial manures supplemented with deep and constant good cultivation.

Apart, however, from the actual fertilizing constituents which the use of farmyard manure brings to the land, there are other considerations which are of the highest importance. These consist in the mechanical and physical benefits conferred on the land by the employment of a material such as farmyard manure. These benefits extend alike to light land and to heavy land. In the case of light-land soils, organic matter, frequently so deficient in them, is supplied, and the needed 'substance' is given to them whereby they become more consolidated and are better able to retain manurial materials subsequently applied. Further, the soil is enabled to retain moisture, and to escape thereby the 'burning up' to which light land and chalky soils are so subject. Nothing in the way of artificial manures could effect this purpose, and in respect of this advantage farmyard manure stands out alone. In the case of heavy and clay soils the advantages, though in a different direction, are no less marked. By the use of farmyard manure heavy soils are rendered easier of working, they are kept 'open' in texture and thereby lightened in character, while drainage is improved and the soil is more exposed to the beneficial influences of warmth, aeration, and oxidation. Such soils, therefore, will no longer suffer, if farmyard manure be applied, from the great drawbacks to heavy land, viz. coldness, difficulty of 'working', and imperfect drainage. This, again, cannot be effected by any use of artificial manures. Farmyard manure accordingly serves a unique purpose both with light land and with heavy land, adding bulk to and consolidating the former, making it richer in vegetable matter and retaining moisture and manure, and making it less liable to lose fertility by drainage; whilst

with heavy land it opens it out, makes it more friable and less liable to stagnation and water-logging through deficient drainage. For light land, well-rotted or 'short' manure is that which should be used, inasmuch as 'long' manure would tend to keep the land too 'open'. The manure being broken down and in an advanced stage of decomposition, its constituents are immediately available, and so it should, in the case of light land, be applied in the spring, just preparatory to the putting-in of the crop to be grown. In the case of heavy land it is preferable to apply the freshly made or 'long' manure, and this at the back end of the year, so that the manure, by its gradual decomposition and the breaking down of the straw, may open the soil, and thus render it more friable and porous. Further, there is not the likelihood, on the heavy land, of that loss of constituents which would occur in the case of light soils were farmyard manure applied in the winter season. On light land the manure is needed for immediate use, accordingly well-rotted manure is used, and preferably in spring; whilst on the heavy land the more freshly made manure is employed to better purpose, and is put on in the winter months. The beneficial influence of farmyard manure in these directions is well exemplified in the growing of root crops, the retention of moisture in the case of light land being quite essential for the starting of the young plant, while, on heavier land, but for the lightening of the soil effected by the free use of farmyard manure, it would be frequently impossible to grow a crop of roots. In potato growing, the culture of vegetables generally, and in market-gardening in particular, farmyard manure of one kind or another is almost indispensable. Its value on grass land and on young clover leys is also indisputed, and indeed it may be said that frequently the best way to utilize farmyard manure is to put it on grass land and to employ artificials more for arable land, for no artificial manure has been found to effectively replace farmyard manure for the growing of a hay or clover crop. Even with corn crops, the long-continued experiments both at Rothamsted and at Woburn testify to the good results obtained from its use. It is true that higher yields of both wheat and barley are procured at both stations from the use of artificial manures, but, even up to the present time, whenever there is a season of drought the highest yields of corn on the light sandy land of Woburn are obtained on the farmyard manure plots, this being due, no doubt, to the retention of moisture by the manure.

A still further point in regard to farmyard manure is its duration, it being what the farmer would call a 'lasting' manure, and not exhausting its effect in a single year, like nitrate of soda, for example. The experiments at Rothamsted and Woburn bear ample proof of this, and at the Woburn experimental farm it has been shown that the application of a dressing of about 7 tons of well-made cake-fed manure for five years in succession (1877–81) continued to show its influence for a period of over twenty years subsequent to the discontinuation of its use.

In yet another respect does farmyard manure differ from artificial manures, in that it is bringing on to the soil numerous organisms which exercise an influence in stimulating the soil's activity. These organisms, while taking their part in rendering the constituents of the manure available for plant use, contribute also to the amelioration of the soil by the setting free of its constituents. Thus, as we have seen, the organic vegetable and animal residues of farmyard manure are constantly being broken up and converted into 'humus', which in its oxidation produces carbonic acid, water, nitric acid, &c., bodies capable of supplying food for plants. These changes are brought about not merely by chemical action, but mainly through the direct agency of minute organisms. Similarly, these organisms are capable of acting on the organic matter stored up in the soil, and of rendering it available for plant use. The presence of another group of organisms is necessary for the exercise of the power of fixing free nitrogen, and for the utilization of this by certain plants, as seen in the case of the Leguminosæ. (See also MANURES, BACTERIOLOGY OF).

The quantity of farmyard manure used per acre varies greatly in different parts of the country, and is regulated more by what is available than by anything else. There is, indeed, great vagueness on this point, 'twelve loads', 'fifteen loads', 'twenty loads', and so on, per acre, being spoken of with but little regard to what a 'load' really consists of. The application of farmyard manure to the land is mostly done by carting out into small heaps and subsequent forking by hand over the land, or by laying it—as in the case of potatoes—in the drill. Many attempts have been made to introduce machines for the distribution of farmyard manure over the land, but, up to the present, none of these has proved really efficient or come into general use. [J. A. V.]

UTILIZATION OF FARMYARD MANURE.—The most economical method of utilizing the farmyard manure that is made in large quantity on every stock farm, and which is most generally employed in the growth of turnips, potatoes, or other roots, has been the subject of investigation in numerous experiments carried out by Professor Wright in the west of Scotland. In these experiments it was sought to establish satisfactory conclusions as to such important points of practice as: (1) the most economical and profitable quantity in which farmyard manure may be applied to the various crops; (2) the crop or crops which on the average of seasons and yields would give the greatest return for the farmyard manure applied; and (3) the best time and manner of application. The results that have been obtained, and the recommendations that have been made with regard to the last of these questions, viz. the best time and manner of applying farmyard manure, are embodied in the article on winter manuring (see WINTER MANURING), and it is therefore unnecessary to refer further to them here.

With regard to the quantity to be applied, the whole evidence of the accumulated data

points to the advisability of employing small dressings, supplemented by suitable combinations of artificial manures, rather than large dressings alone or with artificials added. In one series of experiments on turnips, conducted on thirty-four farms, a dressing of 20 tons of farmyard manure alone was tried against a dressing of 10 tons supplemented by 4 cwt. of superphosphate, and the yields from both plots were compared with that from a plot which received no manure. On the plot which received the single large dressing of farmyard manure, an average increase of crop of 9 tons 17 cwt. 1 qr. per acre was obtained, of a value, at 10*s.* per ton, of £4, 18*s.* 7*d.*; *i.e.* for each ton of the manure there was recovered in the crop of roots a sum of 4*s.* 11*d.* On the plot which received the 10-ton dressing combined with 4 cwt. superphosphate, the crop was on the average 9 tons 15 cwt. 3 qr. per acre greater than on the unmanured plot, and this increase had a value, at the same rate as before, of £4, 17*s.* 10*d.* Deducting the cost (12*s.*) of the superphosphate, there remained a return of £4, 5*s.* 10*d.* to be credited to the farmyard manure, which is equal to a return of 8*s.* 7*d.* per ton when applied in this manner, as compared with the return of 4*s.* 11*d.* when the manure was used as a single large dressing.

Further experiments confirm the view that where suitable artificials are applied to crops along with farmyard manure it is only necessary to apply the latter in limited quantity, and if that quantity be increased, the increase produced is not commensurate with the cost incurred, and gives a reduced return for the manure. By employing a half-dressing, a given quantity can be spread over twice the area it can cover when applied as a full dressing, while by adding artificials the yield can be maintained, and in many cases increased. In this way the productive capacity of a farm may be greatly increased, and if this added production be consumed on the farm, there will be a corresponding increase in the number of live stock that can be maintained, and of the manure that will be produced by them. The use of artificial manures can thus be made the indirect means of greatly enlarging the production of farmyard manure, and so of supplying the best means for the permanent maintenance and improvement of the condition of the soil.

Corroborative evidence as to the superior efficacy, economy, and profit of the light dressing, supplemented by artificials suitable to the crop, was furnished in many of the experiments on the manuring of potatoes reported on by Professor Wright. In one series, carried out on nineteen farms, there was obtained for farmyard manure, applied at the rate of 20 tons per acre to potatoes, a return in the crop of the value of 9*s.* 6*d.* per ton; when applied at the rate of 10 tons, of 19*s.* 11*d.* per ton; and when applied at the rate of 10 tons, with suitable artificial manures added to it, £1, 5*s.* 3*d.* per ton. The 10 tons of farmyard manure alone increased the yield of crop by 3 tons 9½ cwt., as compared with a further increase of 1 ton 11 cwt. only when the quantity of manure was doubled. The effect of the second 10 tons was therefore much less than that produced by the first 10 tons. In ordinary farming conditions, where the quantity of farmyard manure available is limited, and generally inadequate, it is beyond dispute that when applied to potatoes, just as in the case of turnips, the 10-ton dressing, with suitable artificials added, is by far the more profitable method of utilizing it. It has also been shown that the light dressing along with artificials yields a better quality of tuber both in regard to its content of starch and dry matter and also to its cooking quality.

The foregoing conclusions do not of course hold good of farms so situated that unlimited quantities of stable or slaughterhouse manure can be purchased from cities and put on the fields at a low cost. But the majority of farms are not so situated, and it thus becomes a matter of first importance to use the farmyard manure made on the farm in such a manner as to obtain from it the maximum return which it is capable of yielding. From the results of the experiment on potatoes just cited, which are by no means exceptional, it is legitimate to infer that a farmer who is applying 100 tons of farmyard manure to his fields would, by applying this quantity in large dressings of 20 tons per acre, subject himself to a loss of £78, 15*s.*, as compared with the returns he would obtain by applying the manure in half-dressings supplemented with artificials. The method of applying farmyard manure in light dressings, having the twofold advantage of yielding direct returns and immediate profits, and at the same time, especially in the case of a root crop which is consumed on the farm, of indirectly contributing to the maintenance of fertility in the soil, is thus seen to be preferable to the practice of giving to one crop alone a large quantity of farmyard manure, which is not expected to, and does not give a profitable return in the first year of its application, and is left lying unprofitably in the soil, exposed to certain loss and waste.

With regard to the second point at issue—the crops which give the best return for farmyard manure—it may be said that, owing to the fact that crops are not all alike affected by seasons, and also because the market values of the different crops fluctuate, comparisons are difficult to make. But, in general, the prevailing practice of applying farmyard manure to the root crops has been shown by the West of Scotland experiments to be based on accurate observation. Next to them the best returns have been got from timothy hay. Oats and rye-grass hay have not, as a rule, given an equally good return for the farmyard manure applied to them.

[J. B.]

Faroe Islands Sheep. — The Faroe Islands Sheep as now established are descended from an aboriginal wild breed which was characterized by having a fleece of short black curly wool, and flesh of a dark-mahogany colour and peculiar taste. The present breed resemble the latter in their small size, and in having short, stumpy tails. The rams usually have large, strong horns, but the ewes are hornless. The

wool is of various colours, either brown, black, or white, or an admixture of these colours. As in the case of the Shetland sheep, the wool is pulled and not clipped. This breed possesses two coats—an outer coat of long, rather coarse, straight hairs, and an under coat of thick, downy wool through which the outer hairs project. The breed is hardy and active, and well adapted for living on exposed lands and scanty herbage.

Farrier.—Originally the farrier was a skilled horseshoer or smith who professed ability to cure diseases in horses' feet, and latterly to treat of all animal diseases. He was the predecessor of the veterinary surgeon, whose art is still known as farriery.

A farrier or shoer of horses is in England regarded as undertaking a public employment, whereby he becomes bound to serve the public as far as his employment goes, and would be liable for arbitrarily refusing to shoe a horse if brought to him at a reasonable time. In Scotland, however, there is no such obligation on a smith or farrier to undertake work. But in either country the work, if undertaken, must be done properly, and the farrier is liable in damages which result directly from his negligence. He is, however, only bound to bring to the work a reasonable skill and fitness, which he exercises with due and proper care. It is only if the operation has been performed unskilfully and improperly that the farrier will be liable. If there be any peculiar difficulty in the operation known to the owner or custodier of the animal, it ought to be mentioned to the farrier in order that he may understand and take precautions against the risk to which he is exposed. [D. B.]

Farrow and Farrowing.—A litter of young pigs is known as a farrowing. A sow is said to farrow when she brings forth her young.

Fasciola hepatica.—The technical name for the Liver Fluke. See Liver Fluke.

Fast Day, originally a day of mortification and abstinence appointed by the church, whereon work was not lawful. This is no longer law, but the Crown has power to proclaim a day of public fast or thanksgiving, and a bill falling due on such a day is by statute payable on the day preceding. There is no illegality in work done or contracts entered into on such a day (see Sunday). [D. B.]

Fathom, a lineal measure containing 6 ft., formerly used in measuring cordage; now used in measuring depths of sea, water in mines, &c.

Fats are compounds containing carbon, hydrogen, and oxygen, and when dropped in a liquid state on to a piece of paper leave a permanent grease spot. They may be divided into solid fats and fatty oils, the latter being liquid at the ordinary temperature. They differ from the mineral oils in their chemical composition, being compounds of organic acids with glycerine. Fats are therefore esters or ethereal salts, called glycerides. The mineral oils are hydrocarbons.

The organic acids found in combination with glycerine to produce fats are derivatives of both the saturated and unsaturated hydrocarbons, and are called fatty acids. The following list contains some of the principal fatty acids:—

Saturated Acids.		Unsaturated Acids.	
Acid.	Formula.	Acid.	Formula.
Butyric ...	$C_4H_8O_2$	Acrylic ...	$C_3H_4O_2$
Caproic ...	$C_6H_{12}O_2$	Crotonic ...	$C_4H_6O_2$
Caprylic ...	$C_8H_{16}O_2$	Hypogaeic, Physetoleic	$C_{16}H_{30}O_2$
Capric ...	$C_{10}H_{20}O_2$		
Lauric ...	$C_{12}H_{24}O_2$	Oleic ...	$C_{18}H_{34}O_2$
Myristic ...	$C_{14}H_{28}O_2$	Erucic, Brassic ...	$C_{22}H_{42}O_2$
Palmitic ...	$C_{16}H_{32}O_2$		
Stearic ...	$C_{18}H_{36}O_2$	Linoleic ...	$C_{18}H_{32}O_2$
Arachidic ...	$C_{20}H_{40}O_2$	Linolenic ...	$C_{18}H_{30}O_2$
Carnaubic ...	$C_{24}H_{48}O_2$	Ricinoleic ..	$C_{18}H_{34}O_3$
Cerotic ...	$C_{27}H_{54}O_2$		

Fats are esters composed of glycerine combined with fatty acids. Glycerine has the chemical formula $C_3H_5(OH)_3$, and can combine with three molecules of a monobasic acid. The fatty acids are monobasic; therefore in a fat, one molecule of glycerine is a combination with three molecules of a fatty acid, as shown in the following equation:—

$$\underset{\text{Glycerine.}}{C_3H_5(OH)_3} + \underset{\text{Stearic acid.}}{3C_{18}H_{36}O_2} = \underset{\text{Fat (Stearin).}}{C_3H_5(C_{18}H_{35}O_2)_3} + 3H_2O.$$

The fat stearin, as seen above, contains three molecules of stearic acid, and is called glycerine tri-stearate; the same applies to all the fats, thus the fat butyrin is glycerine tri-butyrate, and palmitin is glycerine tri-palmitate, &c.

When fats are treated with superheated steam, or boiled with aqueous solutions of alkalis, such as soda, potash, baryta, or lime water (in presence of alcohol), with lead oxide or strong mineral acids, they are broken up into glycerine + the free fatty acids or their salts. This decomposition is called *saponification*. The sodium or the potassium salt of the fatty acid is soap; caustic soda when boiled with solid animal fats, vegetable fats, or free oleic acid gives hard soap, whilst caustic potash when boiled with fish oils or vegetable drying oils gives soft soap. Saponification may then produce soap and glycerine when caustic soda or caustic potash is used as the saponifying agent, as seen in the following equation:—

$$\underset{\text{Fat (Stearin)}}{C_3H_5(C_{18}H_{35}O_2)_3} + \underset{\text{Caustic soda}}{3NaOH} = \underset{\text{Glycerine.}}{C_3H_5(OH)_3} + \underset{\text{Soap (Sodium stearate).}}{3C_{18}H_{35}O_2Na.}$$

When fats are decomposed with superheated steam or free mineral acids, glycerine and the free fatty acid is liberated as seen below:—

$$\underset{\text{Stearin.}}{C_3H_5(C_{18}H_{35}O_2)_3} + \underset{\text{Water.}}{3H_2O} = \underset{\text{Glycerine.}}{C_3H_5(OH)_3} + \underset{\text{Stearic acid.}}{3C_{18}H_{36}O_2,}$$

water being taken up in the reaction. In order to separate the soap from other bodies, brine in which many soaps are insoluble is added; this causes the soap to separate out.

Fats are insoluble in, and are therefore not miscible with water. The fat in milk is in a state of emulsion. Fats are only slightly soluble in cold alcohol, but their solubility is much increased in hot alcohol. They dissolve readily in ether, chloroform, carbon disulphide, benzine,

turpentine, and petroleum spirit. Castor oil, however, being insoluble in the last-named solvent, is an exception. Glacial acetic acid is a solvent for some oils. Fatty oils are miscible with each other.

Fats being lighter float on water. They cannot be distilled without decomposition, and when heated alone they darken in colour and evolve offensive smelling odours. At 315° C. carbon dioxide and acrolein is given off along with organic acids and hydrocarbons. Fatty oils are not inflammable at the ordinary temperature, but may be burnt by means of a wick in lamps. Pure fats and fatty oils are nearly odourless, of a neutral reaction, and are of a white to a yellow colour. Impure fatty oils vary in colour from a yellow to a dark-brown, and many vegetable oils have a greenish tinge from the presence of chlorophyll. When quite pure, many of the fats remain unchanged when exposed to air, but when impure they often turn rancid; this change being due to the liberation of free fatty acids by microbes, the growth of which is aided by the foreign matter present. Some fatty oils exposed to air absorb oxygen and thicken, forming on the surface a yellowish transparent skin. Such oils are called drying oils, further particulars of which are given later in this article.

Fats occur widely disseminated in both plants and animals. They often form a large proportion of the weight of the organ in which they occur, thus oil-bearing seeds contain from 30 to 50 per cent of oil. Fat animals may contain as much as 40 per cent of their total weight as fat. Both animal and vegetable fats are mixtures of a number of separate fats; thus butter fat is a mixture of nine different fats. Linseed oil is a mixture of three distinct fats, cotton-seed oil of two, &c. The physical and other properties of natural fats must therefore be determined largely by the properties of the predominant fat or fats present. Thus linseed oil is a liquid, because the principal fat it contains is liquid at the ordinary temperature. Mutton fat, butter fat, &c., are solid, because the fats predominating are solids. The odour and taste of fats are not, however, necessarily determined by those of the fats present in largest proportion, for it sometimes happens that such are tasteless and odourless. This property is generally fixed by the presence of some characteristic oil, fat or other body; for example, butter owes its flavour largely to the presence of a relatively small amount of the fat butyrin.

The chemical composition of natural fats, whether occurring in different animals or different parts of the same animal, and even compared with some solid fats in plants, does not show any very marked difference in the percentage of carbon, hydrogen, and oxygen present, though their taste, colour, and smell are often very distinct. This distinction arises from the presence of small quantities of odoriferous and coloured bodies peculiar to the organ in which the fat occurs. A method of identifying fats of different origin is based upon the properties of the products yielded on saponification, such as the proportion of volatile to non-volatile, soluble to insoluble, and saturated to unsaturated fatty acids present. These differences along with others afford a useful test for distinguishing butter fat from lard, &c.

Animal fats are extracted from the organs in which they occur (1) by melting the chopped-up material in open kettles over the fire—the solid impurities float on the top and are skimmed off; (2) by boiling with water, to which some sulphuric acid has been added to decompose the cell walls; (3) by heating with steam under pressure in large digesters—this breaks up the cells and sets free the fat. Animal fat occurs distributed to a greater or less extent throughout all the organs of the body. It accumulates more particularly in the large cells of the connective tissue, and masses of connective tissue thus loaded with fat are called adipose tissue. This tissue is found principally round the liver and underlying the skin. The epithelium cells of the milk glands produce large amounts of fat.

Vegetable oils are extracted (1) by crushing and grinding that part of the plant richest in oil, and then pressing the ground material at a slightly elevated temperature, thus squeezing out the fat; (2) by dissolving out with some solvent, such as benzine, naphtha, ether, carbon disulphide, &c.; after distilling off the solvent, the fat remains.

The refining or purification of fats and oils is effected in various ways, according to their origin and to the impurities present. The following is a list of different methods applicable: (1) Heating, (2) filtration, (3) washing with water, (4) treatment with acids or alkalis, (5) treatment with oxidizing or reducing agents, (6) with precipitants. Vegetable oils and fats are found mostly stored up in seeds. Fats and oils may suitably be classified into classes or groups, based upon their origin, physical characters, and chemical constitution. Thus we get the following groups:—

1. *Olive-oil group, or vegetable oleins.* — This group includes olive oil, olive-kernel oil, almond oil, peach oil, apricot oil, earthnut oil, and tea-seed oil.

These oils are used for lubricating, burning, greasing, soapmaking, ointments, &c.

2. *Rape-oil group.*—These oils are all derived from cruciferous plants, and include rapeseed or colza oil, cabbage-seed oil, radish-seed oil, oil of black mustard, oil of white mustard, Jambo oil.

3. *Cottonseed-oil group.*—These are semi-drying oils, and include cotton-seed oil, cress-seed oil, grapeseed oil, maize oil, sesame oil, sunflower oil, hazelnut oil, Cambria oil, and beechnut oil.

4. *Linseed-oil group, or drying oils.*—These oils on exposure to air absorb oxygen and form varnishes; at first they are sticky, but when spread in thin layers the stickiness soon disappears. They include linseed oil, hempseed oil, poppy-seed oil, tobacco-seed oil, niger-seed oil, walnut oil, Scotch-fir-seed oil.

5. *Castor-oil group.*—Some of these oils have purgative properties. They include castor oil, croton oil, curcas oil, Japanese or Chinese wood-oil, boiled linseed oil, blown oils.

6. *Palm-oil group.*—These include palm oil, cacao butter, nutmeg butter, bayberry tallow, Chinese tallow.

7. *Cocoanut-oil group.*—These are mostly solid vegetable fats, and include cocoanut oil, laurel oil, macassar oil, Japan wax, myrtle wax.

8. *Lard-oil group, or animal oleins.*—Liquid at the ordinary temperature, and include neat's-foot oil, bone oil, lard oil, tallow oil, horse-foot oil.

9. *Tallow group, or solid animal fats.*—They include tallow or suet, lard, horse fat, bone fat, wool fat (suint), butter fat, margarine, stearin.

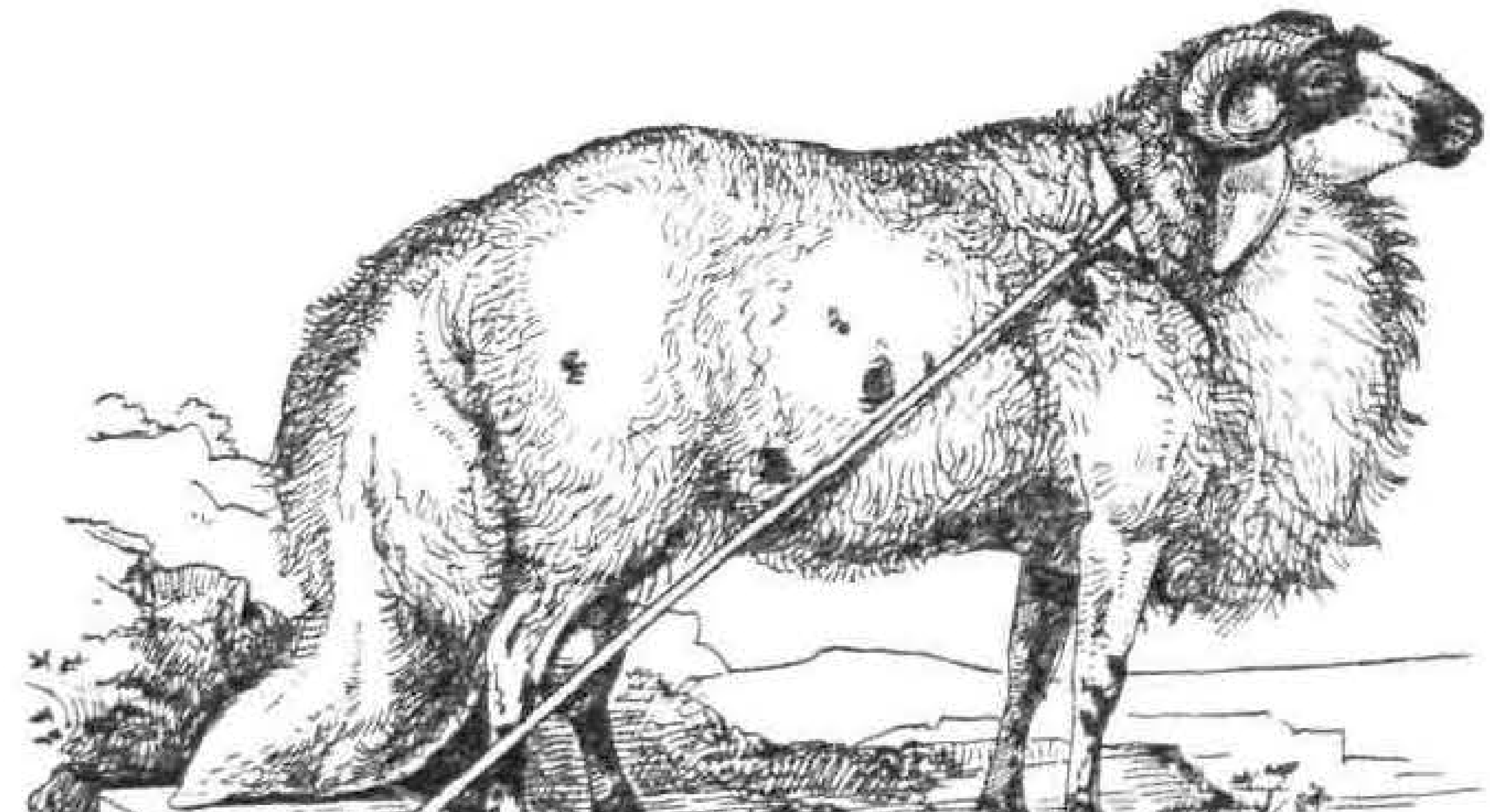
10. *Whale-oil group, or marine animal oils.*—These oils somewhat resemble the cotton-seed group of oils, and include whale oil, porpoise oil, seal oil, menhaden oil, cod-liver oil, shark-liver oil.

The following are some of the principal uses of fats and oils, lubricating, greasing, food, cooking, soapmaking, ointment, emulsions, margarine, pharmacy, wool dressing, perfumery, painting, varnishes, oilcloth making, medicine, drying oils, chocolate creams, night lights, artificial butter, candlemaking, veterinary medicine, leather dressing.

Fats and oils constitute one of the principal classes of foodstuff, and are in that respect of considerable commercial value. See also OILS.

[R. A. B.]

Fat-tailed Sheep, sometimes also called Flat- or Broad-tailed Sheep, are a domestic breed characterized by the development of a quantity of subcutaneous fat upon the tail. The name *laticaudata* has been given to this variety. It is very widely distributed, and occurs in Barbary, Syria, Arabia, Afghanistan, India, and various parts of Africa. It is possible that Syria was its original home, for both Herodotus and Aristotle speak of it in connection with that country; and passages from the Old Testament prove it to have been the domestic sheep of the ancient Israelites. According to Tristram it is still common in the southern parts of Syria, and is said to be tall, large boned, and to possess a long Roman nose. The ewes are hornless; but the rams have well-developed horns curling behind the ears, which are long and pendulous. The colour may be black, brown, or white, but is usually white with black markings. The coat is woolly, and that of the fœtal lamb constitutes the fine curly wool known in commerce as *astrachan*. The whole of the tail, with exception of a few inches at the extremity, is enveloped laterally in a mass of fat, and hangs like a double cushion over the hind quarters, completely concealing the buttocks. It may weigh from 10 to 14 lb., and is frequently supported on a piece of board run on wheels. There appears to be more than one variety of this sheep. The Dhoomba or fat-tailed sheep of India, for example, is a small breed with shortish legs, and small horns in the ram. The bones of the tail, moreover, form a decided sigmoid flexure backwards and upwards, so that the narrow tip is carried at about the same level as the docked tail of English sheep. This variation may, however, be due to artificial cutting of the tendons. On superficial examination these sheep appear to belong to the fat-rumped breed, with which the fat-tailed breed seems sometimes to have been confused. In Liberia, Sir Harry Johnston speaks of a fat-tailed sheep which is coated with hair instead of with wool, and is usually of a uniform reddish-brown hue. The fat of the tail of the Syrian sheep is said to resemble lard, and to be semi-fluid in consistency. By the Arabs it is eaten fried in slices, and is used for lamps, lubricating, cooking, and other purposes. Fat-tailed sheep have also been recorded from Abyssinia and various parts of South Africa, and in the latter country are sometimes called Hottentot sheep.



Fat-tailed Sheep

The fat-rumped sheep of Tartary and Central Asia must not be confounded with the breed just described. The tail is practically absent, or reduced to a button-like knob which is almost concealed by a pair of hemispherical masses of fat accumulated on the buttocks and sometimes weighing as much as 30 lb. In allusion to this peculiarity, the name *steatopyga* has been given to this breed. As in the fat-tailed sheep, the colour varies, sometimes being black, sometimes white, but more commonly the body is white and the head black. The coat, as a rule, appears to be hairy and not woolly. The ears are pendulous, and there is commonly a goitre-like accumulation of fat on the throat.

[R. I. P.]

Fattening of Farm Animals.—

GENERAL CONSIDERATIONS.—The food of an animal must primarily satisfy the following requirements: (*a*) It must provide for the renewal of worn-out tissue, and the manufacture of any new tissue required for normal growth. (*b*) It must generate in the animal sufficient heat to counterbalance the losses by radiation and evaporation, in order to maintain the body tempera-

ture practically constant. (*c*) It must supply the energy required for the performance of the mechanical and chemical work involved in the activities of the various organs of the body (*e.g.* movements of the heart, lungs, &c., digestion changes, &c.), as well as for any muscular exertion performed by the animal (see NUTRITION OF ANIMALS). These requirements are commonly referred to as the 'maintenance requirements' of the animal. If the food supplied to the animal be insufficient in amount or nature to meet these requirements, the deficit must be made good out of the tissues already formed in the body, and in the case of young animals growth is retarded or even suspended. If, on the other hand, the food supply is in excess of the above requirements, a portion of the excess is practically burnt up in the body with production of waste matters and heat, whilst the rest is stored up in the body as new growth, causing *increase of live weight*. In short, when the food supply is in excess of the maintenance requirements the animal 'fattens'.

The *amount and character of the 'fattening increase'* thus produced from a given excess of food varies greatly with different classes of animals and with different individuals of the same class.

Of the three animals commonly fattened on the farm, the pig effects by far the most economical conversion of food into meat, whilst the ox is least efficient in this respect. This is well exemplified in the following data (Warington) based upon the experiments of Lawes and Gilbert, and representing the average of the whole period of fattening:—

	Per 1000 lb. live weight per week.			Required to produce 100 lb. increase.	
	Dry food consumed.	Digested organic matter consumed.	Increase in live weight.	Dry food.	Digested organic matter.
	lb.	lb.	lb.	lb.	lb.
Oxen ...	125	88	11·3	1109	777
Sheep...	160	121	17·6	912	686
Pigs ...	270	227	64·3	420	353

In brief, whereas according to these estimates the pig increases in live weight, on the average, 1 lb. for every 3½ lb. organic matter digested by it, the ox requires nearly 8 lb. of digestible organic matter to produce a similar increase. The difference is, however, largely accounted for by the more concentrated and more easily digestible ration fed to the fattening pig. For it must be remembered that the energy required for the processes of mastication and digestion is a first charge on the food supply, and hence the surplus available for the production of fattening increase will be relatively much less in the fattening ration of the ox, with its large proportion of coarse fibrous material, than in the case of the pig. The pig has, however, the further advantage of a digestive apparatus specially adapted for the rapid assimilation of large quantities of easily digested food, so that even when due allowance is made for the difference in the nature of the food, the pig must still be regarded as the most efficient meat-producing animal on the farm.

The great individual variations in the fattening capacity of animals of the same class and even of the same breed are matters of common observation. Thus in an experiment at Garforth the individual 'increases' obtained during five months with six cross-bred Shorthorn bullocks receiving identical rations ranged from 221 lb. to 353 lb. These variations are partly due to differences in appetite and digestive powers, but must in the main be attributed to less easily traceable differences in constitution and nervous temperament.

The improvement in the fattening qualities of different classes of animals that can be effected by judicious breeding and treatment is strikingly exemplified in the history of the well-known breeds, notably of pigs. Thus, whereas it is practically impossible to fatten the wild boar, its domesticated descendant, bred with a view to rapid fattening, can be made to put on weight at the rate of as much as 1½ to 2 lb. per day.

The rate at which an animal receiving a liberal ration will increase in weight is directly affected by its *age*, the rate of increase steadily falling as the animal matures. Thus whereas the suckling calf may increase by as much as 3 lb. per day, the daily rate of increase of the yearling steer will as a rule be not much more than 2 lb., whilst after it has reached the age of two years, and practically completed its growth, the rate of increase will fall very markedly. Similarly, during the actual fattening period the amount of food required to produce a given increase in live weight steadily increases as the fattening progresses, the amount required being frequently more than doubled before the end of the period. This is well illustrated by the following data, quoted by Warington, from the results of pig-feeding experiments at Rothamsted:—

	Food consumed.		Food producing 100 lb. of increase.
	Per head.	Per 100 lb. live weight.	
	lb.	lb.	lb.
First fortnight...	60·1	39·7	386
Second ,, ...	67·5	36·7	388
Third ,, ...	66·4	30·9	502
Fourth ,, ...	66·0	27·4	511
Fifth ,, ...	69·6	26·3	618

This steady rise in the weight of food required to produce a given 'increase' as fattening progresses is largely explained by the fact that whereas, in general, the amount of food consumed by the fattening animal remains practically stationary after the first few weeks, and even falls somewhat when the animal becomes very fat, the demands upon the food for simple maintenance steadily increase with the increasing size of the body. The maintenance requirement is indeed much higher for a fat animal than for a lean one of similar weight, owing to

the greater strain placed upon the vital organs in the former case.

A further contributory cause of the apparent falling-off in the fattening efficiency of the food is the drier nature of the increase in the later stages of the fattening, when water is being steadily replaced in the tissues by fat. The increase in live weight corresponding to each pound of dry substance produced from the food must obviously on this account tend to diminish. The falling-off will be further accentuated by the fact that the water displaced from the tissues by the fat will be lost from the body. When the weight of water displaced becomes equal to *the weight of fat deposited, the animal will cease* to gain in weight, and the further progress of the fattening can then only be judged by the expert feeder, who can estimate by eye and hand the thickness of the fat layer at different parts of the body. It is very rarely, however, that fattening is pushed to such an extreme limit. When the tissues are loaded to their maximum capacity with fat, a reaction against further fat production will gradually set in, and the amount of food consumed will decrease.

The foregoing observations are of far-reaching importance in their bearing upon the practical aspects of fattening. The cost of fattening must obviously be greater, in general, the older the animal to be fattened, and the more prolonged the period of fattening. Unduly prolonged fattening will indeed be wasteful in a double sense, for not only will the last few pounds of gain be obtained at ruinous cost of fattening food, but the absolutely unprofitable expenditure on food for the simple maintenance of the animal will also be unnecessarily prolonged. Therefore, within the limits imposed by financial and other practical considerations, rapid fattening, even though it involves liberal feeding, is likely to prove as a rule the most economical.

Having dealt thus far solely with the *amount* of increase produced under different conditions, we have now to consider the *nature* of the fattening increase, and more particularly the proportion of lean flesh or muscle to fat in it. This varies greatly with the age of the animal and its 'condition' at the beginning of the fattening period.

In the case of young growing animals the fattening is accompanied by the normal growth of the animal, which will consist mainly of muscular and other nitrogenous tissues and bone, causing the fattening increase to contain an appreciable proportion of nitrogenous matter (lean flesh).

Similarly, with adult animals in very lean condition at the outset of fattening, the first effect of the heavier feeding will be chiefly to develop the muscular tissues; but the limit set by biological laws to the development of the frame of the animal will soon be reached, and once raised to fair condition, the subsequent increase must be almost entirely fat. In the case of the full-grown animal in fair condition, the muscular tissues will, however, admit of but little augmentation, and the material stored up from the food must hence in this case from the very outset consist chiefly of fat. These facts are well illustrated by the results of analyses by Lawes and Gilbert of the bodies of a number of animals (see art. ANIMAL CHEMISTRY).

From these data Lawes and Gilbert also calculated the percentage composition of the increase in live weight of oxen, sheep, and pigs, when passing from the 'store' to the fat condition, with the following results:—

	Water.	Nitrogenous matter.	Fat.	Ash.
	per cent.	per cent.	per cent.	per cent.
Oxen ...	24·6	7·7	66·2	1·5
Sheep ...	22·0	7·2	68·8	2·0
Pigs ...	28·6	7·8	63·1	0·5
Average ...	25·1	7·6	66·0	1·3

It will appear from these data that with animals comparable in respect of age and condition, the composition of the fattening increase is much the same for the three classes of stock. The animals in question were mostly young or not fully grown, and yet it will be noted that two-thirds of the increase is fat and only one-thirteenth is nitrogenous matter. Of this latter an appreciable proportion would be attributable to the increase of the blood supply which accompanies fattening, so that the balance representing lean flesh produced must have been very slight indeed.

The proportion of lean to fat may be affected to some extent by the character of the feeding, but only in the case of rapidly growing young animals. Such animals will give a rather greater proportion of lean to fat on a diet rich in albuminoids than on one poor in these ingredients. Full-grown animals, however, will lay on practically nothing but fat whether the diet be rich or poor in albuminoids.

In general, then, the food of the fattening animal must be adapted for the production of an abundance of body fat and a smaller amount of muscular tissue or lean flesh—the proportion of the latter to the amount of fat produced being in all cases small, and in the case of full-grown animals almost negligible.

Before we can fully discuss the nature and amount of the food which may be expected to achieve these ends most efficiently and economically, it will be necessary for us to consider briefly the relative values for fattening purposes of the different ingredients of foods, viz. albuminoids, oils, carbohydrates, and fibre (see art. ANALYSIS). We are indebted for information on this point mainly to the work of German investigators, culminating in the masterly researches of Kellner and his associates.

In these experiments with full-grown oxen, typical representatives (wheat gluten, earthnut oil, starch, sugar, pulped straw) of each class of food ingredients were obtained and added singly to a ration on which the animal was just slightly gaining in weight. The amounts of lean flesh and fat produced daily were determined with the greatest possible accuracy both before and after the addition of the extra food

(starch, oil, &c.). The difference between the two gains was then taken as a direct measure of the fattening effect of the added food. The average results arrived at in this way are summarized in the following table, the figures given in the third column of the table representing the weights of fat (with allowance for any lean flesh) produced by the animal from every 100 lb. of the food ingredient digested. The last column gives the results in the form of percentages of the maximum amounts obtainable.

Nature of food ingredient.	Substances actually used in the experiments.	Weight of 'fat' produced per 100 lb. of food ingredient digested.	Percentage ratio of the energy stored up in the form of increase to the total amount of energy supplied by the digested food.
		lb.	per cent.
Albuminoid...	Gluten ...	23·5	48
Oil	Earthnut oil	59·8	64
Carbohydrate	Potato starch	24·8	56
	Cane sugar ...	18·8	45
Fibre ...	Pulped rye straw	25·3	57

It will be noted that, according to the results of these experiments, digestible oil would appear to be by far the most prolific fat-producing ingredient of foods; then come, practically equal in value, the insoluble but easily digested carbohydrate, starch, and the easily digested pulped straw, which contained 77 per cent of crude fibre, and was thus practically a preparation of 'fibre'. Next, and slightly inferior to the starch and pulped fibre, comes the albuminoid, and lowest of all, the soluble, easily digestible and fermentable carbohydrate, sugar. Putting the fat-producing value of starch = 100, we arrive at the following figures for the relative values for the fattening of oxen of the different food ingredients when supplied in easily digestible condition:—

Starch...	100
Fibre (pulped straw)	102
Sugar	76
Albuminoid	95
Oil	241

Attention may also be directed to the data in the last column of the table, which are of interest as showing in each case how much of the energy placed at the disposal of the animal in the form of digested food was retained by it in the form of increase. It will be seen that when their respective powers of supplying energy to the animal are taken into account, the differences between the fat-producing powers of the different ingredients of food are much less pronounced than when compared on the basis of equal weights, but still the relative order of efficiency remains unchanged, the increase actually produced ranging from 64 per cent of the maximum possible in the case of the oil, down to 45 per cent in the case of the sugar. In other words, the waste of food, so far as fattening is concerned, ranged from 36 per cent in the former case up to 55 per cent in the latter case.

It is thus clear that, even when the food ingredients are supplied in easily digestible form, a very considerable proportion of the energy which they convey to the animal is diverted from the process of fattening. This proportion must obviously increase (and the balance available for fattening correspondingly decrease) with any increase in the energy required for other purposes than fattening, *e.g.* the mastication and digestion of the food.

This is strikingly illustrated by the following data selected from Kellner's experiments. In the table the fattening values (compared with starch) of a number of foods, as actually found by experiment, are contrasted with those calculated from the percentages of digestible albuminoids, oil, &c., in the foods, by crediting these with the relative fattening values given above. In the calculations due allowance has been made for the high proportion of sugar included in the carbohydrates of the mangels, and for the non-oily matters included in the 'oil' (see art. ANALYSIS) of the foods other than the oil meals.

Food.	'Starch value', *i.e.* weight of starch (in lb.) equivalent, for fattening purposes, to 100 lb. of the food (Kellner).		Actual starch value (*b*) expressed as percentage of calculated starch value (*a*)
	(*a*) Calculated.	(*b*) Found.	
	lb.	lb.	per cent.
Decor. cotton-seed meal	80	79	98
Linseed-cake meal ...	79	77	97
Bean meal	69	65½	95
Rye meal	72½	68	93
Dried grains	62	52	84
Wheat bran	62	48	77
Potatoes	74	72½	98
Mangels	60	52	87
Meadow hay	57	38	67
Oat straw	43½	26½	60
Wheat straw	37	9	24

It will be noted that in every case the calculated values are higher than those actually found; but that whereas in the case of the easily digested foods (*e.g.* the oil and cereal meals and potatoes) the differences are so slight as to be practically negligible, they are much greater with the more fibrous foods, and reach their maximum in the case of the hard, difficultly digestible straws.

It is thus obvious that, except in the case of the soft, easily digested foods, an appreciable portion of the energy which would, under favourable conditions, be stored up as increase, is diverted to serve other purposes, the chief of which is undoubtedly the provision of the energy required to ensure thorough mastication and digestion.

It is clear, however, from the close agreement between the 'calculated' and 'found' values in the case of the easily digestible foods, that the individual nutrients have, when mixed together (as in foods), the same relative powers of sup-

plying to the animal energy which, if no other demands have to be met, can be stored up in the form of fattening increase, as they were found to have when fed separately. It is safe, therefore, to assume that the discrepancy between the calculated and observed fattening values in the case of the less easily digested foods is not *due to any inferiority of their digestible albuminoids*, carbohydrates, &c., as compared with the corresponding ingredients of the more easily digested foods, but is chiefly attributable to the mechanical condition of the food (notably the fibre) and other factors, which make inroads upon the materials supplied by the food and thus reduce the balance available for fattening.

The figures in the last column of the table may be used as correction factors, whereby the starch values calculated from the percentages of digestible nutrients in the foods can be brought into harmony with the observed starch values. Thus, if a certain sample of bran contain 10 per cent of digestible albuminoids, 3 per cent of digestible oil, and 45 per cent of digestible carbohydrates (+ fibre), its starch value, assuming the different nutrients to exert their full effect, would be $[(10 \times \frac{94}{100}) + (3 \times \frac{241}{100}) + 45]$ lb., or 61·7 lb. According to the table, however, the actual starch value will be only 77 per cent of this, or 47·5 lb. The reader will find such correction factors tabulated for a great variety of foods in Kellner's Ernährung der landwirtschaftlichen Nutztiere (or his smaller work, Grundzüge der Fütterungslehre), to which he is referred for further information on this subject.

Before leaving the subject it is necessary, however, *to point out that Kellner's experiments* were made exclusively with oxen, and hence his results do not necessarily hold good for other classes of stock. Evidence is rapidly *accumulating, however, which indicates that the relative* fattening values of the different nutrients are much the same for different classes of stock, so that it appears justifiable to use the *same values in dealing with sheep and pigs.*

From the facts now discussed we can derive very clear guidance as to the nature of the food which may be expected to prove most efficient and economical for fattening purposes in general.

We will consider first the supply of *albuminoids* to the fattening animal.

The fact may be recalled that the fattening increase consists chiefly of fat, and contains very little nitrogenous (albuminoid) matter. Further, we have seen that albuminoids, even under the most favourable conditions, are inferior as fattening foods to easily digestible oils or carbohydrates. On the other hand, it must be borne in mind that the albuminoids (lean flesh) of the animal body can be produced *only* from the albuminoids of the food, and hence albuminoids cannot be entirely excluded from the fattening ration. This must obviously contain at least sufficient albuminoid matter to replace that destroyed in the normal wear and tear of the tissues, and to produce the small amount of nitrogenous matter contained in the increase.

The fatty matter of the increase can, however, be produced at least equally well, and as a rule far more cheaply, from the oils and carbohydrates of foods.

It might appear warrantable, therefore, both from scientific and economical considerations, to restrict the supply of albuminoids in the case of the full-grown fattening animal, which produces little but fat, to an amount only slightly higher *than that given for maintenance*, whilst similarly the fattening growing animal would apparently require very little more albuminoid than is necessary to ensure full development of the muscles and frame. This conclusion is, however, not borne out in practice. For if the proportion of albuminoids to non-albuminoids in the ration is as low as this would imply, especially in the case of the adult animal, there is great risk that some of the non-albuminoid (carbohydrate) matter will escape digestion (see later).

Moreover, the heavy rations fed to fattening animals make great demands on the activities of those glands which secrete the digestive juices; and since the active principles of these juices are largely nitrogenous in character, the increased activity must be provided for by an increased supply of albuminoids in the food. In the case of growing animals it is found in practice that rations fairly rich in albuminoids are markedly superior to rations supplying the bare minimum amount of albuminoids, the latter tending to produce a carcass overloaded with fat and of poor quality.

In order to ensure thorough digestion of the food, the albuminoid ratio of the ration should, in general, be not wider than about 1 : 8–10 for oxen and sheep, or 1 : 12 in the case of pigs. *In other words, the fattening ration of full-grown animals in fair condition should contain* at least 1 lb. of digestible albuminoids for every 8 to 10 lb. (12 lb. in the case of pigs) of digestible *non-albuminoid nutrients (including oil × $2\frac{1}{4}$)*.

Growing animals will, of course, require a somewhat higher proportion of albuminoids, since in their case the fattening increase includes the *normal growth* of the animal. Similarly, animals in lean condition will require a ration richer in albuminoids during the early stages of fattening than will be necessary after the muscular tissues have been fully developed.

The proportion of albuminoids indicated above is considerably lower than was demanded by the older German feeding standards, but is more in harmony with practical experience.

If it is desired to give the animals a higher proportion of albuminoids than is suggested above, the amount may be increased, without any detriment to the progress of the fattening, until the albuminoid ratio becomes about 1 : 4, or even somewhat narrower in the case of young animals. It will, however, not be advisable—indeed it will rarely be practicable—to go much beyond this with any but very young animals, since the abundant supply of albuminoids then considerably augments the blood supply, and especially the number of the red corpuscles which carry oxygen to the different parts of the body. The amount of wasteful oxidation occurring in the tissues is thereby increased, and fat formation suffers accordingly. The

practice, referred to by Continental writers, of occasionally bleeding the fattening animal slightly, with the object—amongst others—of accelerating the fattening, finds an explanation in these facts.

Turning now to consider the *non-albuminoid portion* of the fattening ration, this will be made up chiefly of carbohydrates and fibre, since, although oils or fats are pre-eminently the most efficient fat-producing ingredients of foods, and hence should be used as far as possible, they can only be fed in strictly limited quantities, and moreover are expensive to supply.

The supply of *oil* in fattening rations, though thus restricted in amount, is nevertheless a factor of great importance in fattening, and must be dealt with in some detail. The effects of excessive supply of oil or fat in the food in causing loss of appetite and impaired digestion are well known.

The oils are best supplied in the natural form, as in oilcakes, grain foods, &c. In this form the daily ration per 1000 lb. live weight may safely contain $\frac{3}{4}$ to 1 lb. of oil in the case of full-grown animals, or even more than this amount in the case of growing animals.

If the oil is given in separate form, the risk of disturbing the digestion of the animal is greatly reduced by feeding the oil in the form of a fine emulsion.

Equally important with the amount of oil fed is the effect which it is likely to produce on the *quality* of the fattening increase. It is now a well-established fact that many oils and fats when consumed by animals can to some extent be deposited unchanged in the body and thereby impress their character upon the fat produced, the influence being particularly apparent in the case of swine.

This renders it possible for the feeder to influence, to some extent, the character—notably the texture—of the fat produced during the fattening period, by a suitable choice of the oil-bearing foods included in the ration. Thus foods rich in carbohydrates and very poor in oil (*e.g.* rye, barley, peas, beans, potatoes, roots, &c.) tend to produce a hard fat, whilst, apart from oilcakes and meals, the foods richer in oil (*e.g.* oats, maize, wheat offals, rice meal, &c.) show the opposite tendency. Of the oilcakes and meals, cotton-seed cake, cocoanut cake, and palmnut cake have a hardening tendency, whilst linseed cake and rape cake tend to produce a softer fat.

The character of the body fat is also influenced to some extent by the temperature of the surroundings of the animal, exposure to cold tending to produce under the skin a softer fat than is produced when the animal is warmly housed.

The foregoing facts would seem to indicate, therefore, that in the case of oxen and sheep, where the fat is liable to be too hard rather than too soft, the best results will be obtained by the use of foods of the softening class (*e.g.* maize, oats, bran, linseed cake), and maintaining the animals at a temperature moderately low but consistent with comfort; whilst in the case of swine the tendency to undue softness of the fat will best be counteracted by the use of foods such as barley and peas, which have a hardening effect, and by housing the animal in a comfortably warm stall.

It must be remembered, however, that the bulk of the fat produced by the animal must always be manufactured from the carbohydrates and fibre digested from the food. It is hence obviously not to be expected that any profound alteration in the character of the body fat can be achieved by any variation in the nature of the oil fed to the animal. In other words, the fat produced by oxen will still be beef fat whether the oilcake fed be made from linseed or cotton seed, the only difference being that the fat is likely to be rather softer and more appetizing with the former food than with the latter.

The *carbohydrates and fibre* will constitute the greater part of the ration, and hence mainly on them will fall the responsibility for the progress of the fattening.

Attention may again be drawn to Kellner's conclusions as to the relative merits for fattening purposes of the different carbohydrates and of fibre (see p. 175). It is of interest and importance to note from his results that whereas digested fibre can apparently under the most favourable conditions be as profitably utilized by the fattening ox as digested starch, the readily soluble, fermentable carbohydrate, sugar, is decidedly inferior. This will probably also hold good for the sheep, and in a less degree for the fattening pig. It does not apply, of course, to the suckling animal.

With regard to the fibre, we have seen that its value to the animal must depend largely upon its mechanical condition. In the coarsest forms of food, such as the straws, where the labour of mastication and digestion is very great, the fibre can contribute little or nothing to the fattening increase. The proportion of the digested fibre which can be converted into fat will, however, be very considerable in the case of the softer and more easily digested foods.

The amount of *mineral matter*, especially lime and phosphoric acid, supplied in the food is a matter of great importance in the case of growing animals, owing to the requirements of bone formation. The fattening increase itself does not, however, contain much mineral matter, and hence it will suffice if the ash requirements for the general growth of the animal are liberally met by the food.

The *total amount of food* supplied to the fattening animal must be adjusted to the capacity and nature of the digestive apparatus. Thus oxen and sheep, since they have capacious stomachs and intestines, require bulky rations, whereas the pig, having a widely different stomach, must for this and other reasons receive food of a more compact and concentrated nature.

Overfeeding will tend to impair the digestion, ıd to produce a feeling of discomfort which may be highly prejudicial to the progress of fattening.

The amounts of food which will be suitable for different classes of stock must be left largely to the judgment of the feeder, but a rough guide may be obtained from the data for total dry matter, given later in the paragraphs dealing

with the special requirements of different classes of animals.

The food should not contain more *water* than the animals require and would voluntarily consume if granted an unlimited supply. Excessive supply of water may lead to general flabbiness of the tissues, impaired digestion, and weakening of the constitution of the animal. It is commonly stated that, in general, cattle should not consume in the food and separately more than about 5 lb., sheep more than about 3 lb., and swine more than about 8 lb. of water for every 1 lb. of dry matter consumed. Only a portion of this water should be supplied in the food, as the periodical watering which must take place to supply the rest will have an invigorating and otherwise beneficial effect on the animals.

Young animals require a more liberal supply of water than adults, and the requirement will also increase with any rise in temperature of the surroundings of the animal.

The rations employed in fattening are so heavy, that in order to guard against any falling-off in the appetite of the animal special attention must be paid to *palatability* in the selection and preparation of the ingredients of the ration. Salt and treacle are also particularly useful in this connection. If salt is mixed with the food, about 2 oz. per head per day will be a suitable allowance for cattle, and ¼ to ½ oz. for sheep or pigs. The feeding of salt to pigs is, however, apparently attended with some risk. When roots (especially mangels) are fed liberally, there should be no need for salt. In general, a ration made up from a variety of feedingstuffs will be more palatable, more stimulating to the appetite, and hence will give better results than a ration made up from two or three foods only. 'Palatableness, variety, and ease of digestion are the main points to be secured, and these factors have been somewhat overshadowed by the effort to secure merely a definite relation of protein to carbohydrates' (Jordan).

Along with the amount and nature of the food supplied, the *treatment* of the animal is of the utmost importance in fattening.

It will be clear, from the considerations with which this article commenced, that if rapid and economical fattening is to take place, the requirements of the animal for heat and its expenditure of muscular and nervous energy must be reduced to a minimum.

To this end, shelter, rest, freedom from excitement, and attention to all that contributes to the *comfort* of the animal are essential. This is notably the case with young and excitable animals.

It is necessary to allow a certain degree of freedom of movement to the animal, especially if not fully grown, in order to secure perfect development of the frame and muscular tissues, on and in which the fat is being deposited; to strengthen the constitution, and also to reduce the risk of staleness, which too close confinement is apt to induce. Quiet pasturage will usually best serve these objects in mild weather. The facilities for exercise must, however, in any case be strictly limited to this necessary minimum, since all unnecessary exertion involves diversion of an equivalent amount of food from the production of fattening increase to the provision of the energy required for this exertion.

For the same reason the animal should be encouraged to lie down as much as possible by the provision of a dry, comfortable bed. Armsby (1903) found in fact that a bullock required for maintenance practically one-third more food when standing than when lying.

To ensure freedom from excitement the lighting of the stall should be only moderate, and so arranged that the animals are never exposed to the direct radiation of the sun; the hours of feeding and other attendance should be regular and not too frequent; and changes in the amount or nature of the rations should be introduced gradually.

Where the animals are fed under cover, attention to the *temperature* of the stall is also of considerable importance. Extremes of temperature, whether high or low, are wasteful of food, since they cause undue production of heat in the body to make good the losses arising, in the case of low temperatures, from excessive radiation; in the case of high temperatures, from excessive perspiration. The temperature of the fattening stall should be lower rather than higher than for other feeding purposes, since a moderate fattening ration will always produce in the body far more heat than the animal requires under ordinary conditions. If the temperature of the stall be too high, this large excess of heat can be removed from the body only to a small extent by radiation, and the bulk of it must be removed by evaporation of water from the tissues. The hot stall thus increases the amount of water required by the animal, a condition which, for reasons previously explained, is undesirable. If at the same time the evaporation of water from the body is impeded, by deficient ventilation, thick coating of hair, or otherwise, the animal will instinctively guard against the threatened overwarming of its body by reducing its consumption of food, and thereby lowering the rate of fattening. The difficulties of fattening during hot weather are largely due to circumstances of this nature. In winter the most suitable temperature for the stall will, as a rule, be about 50° to 60° F. *The deciding factor must be the comfort of the animal.* In some districts this will probably be best secured on the average by outdoor feeding, with or without the provision of light shelter; in other districts comfortable housing in winter will be absolutely imperative for successful fattening.

Attention to the proper *ventilation* of the stall will be rewarded not only in the more efficient regulation of temperature, but also in the more satisfactory general health of the animals.

In so far as it contributes to their comfort, *grooming* and otherwise attending to the cleanliness of the animals during the stall-feeding period may be expected to have a beneficial influence on the progress of the fattening.

The fattening of animals is thus a process the progress of which is affected by a great variety of factors, based in the main upon definite scientific principles. Knowledge of these scientific principles, and skill in their practical

application, will, however, be of little avail to the feeder unless combined with good judgment in the breeding or selection of animals of the most profitable type, and in gauging to a nicety and utilizing to the full the capabilities of different individuals.

Practical Applications to Different Classes of Stock.—Thus far we have dealt solely with the general principles involved in the fattening of animals. We may now turn our attention to their practical application in the fattening of oxen, sheep, and swine.

The age at which animals are disposed of in fat condition varies greatly in each class, notably in the case of oxen and sheep. Hence it is necessary to again draw attention to the general difference between the requirements for fattening of growing animals and of full-grown animals respectively (see p. 174). It must be remembered that in the case of the full-grown animal, in fair condition at the outset of fattening, the increase will consist almost solely of fat, and hence the fattening food may consist almost entirely of fatty and carbohydrate matters. The food supplied to the growing animal must, however, be such as will not merely enrich the tissues with fat, but will, above all, develop to the fullest extent the possibilities of muscle and bone formation. This is all the more necessary in that the lean flesh is in general the most desirable and valuable part of the carcass, and further, being rich in water, every pound of dry matter stored up in this form means a much greater increase in live weight than if stored in the form of the dry fatty tissue.

This difference between the growing and the mature animal is chiefly met by a more liberal supply of albuminoids and mineral matter (especially phosphates and lime) in the food of the growing animal, and by the exercise of greater care in selecting foods for it in order to ensure that the rations shall be at once appetizing and highly digestible. The young animal will also respond more generously to measures adopted to secure its comfort.

Oxen: Beef Production

Full-grown Oxen.—For convenience of treatment the case of the full-grown ox may be considered first, although, owing to the greater economy of earlier fattening, it is now practically only in the case of dairy cows that fattening is delayed until after the animal has attained full growth.

Full-grown oxen are commonly fattened on a diet of hay, straw, roots, and concentrated foods. According to Kellner, such animals may be expected to make an average daily gain in live weight of 2 lb. per 1000 lb. live weight on a daily ration supplying (per 1000 lb. live weight) 24 to 32 lb. of dry matter containing the following amounts of digestible nutrients:—

Crude albuminoids (*i.e.* including amides).	Pure albuminoids (*i.e.* excluding amides).	Oil.	Carbohydrates + fibre.
lb. 1·8–2·2	lb. 1·5–1·7	lb. 0·7	lb. 13–16

He stipulates further, however, that the foods shall be of such nature and quality that the ration shall have a fattening value equal to 12½ to 14½ lb. of digestible starch. The above ration has an albuminoid ratio of 1 : 9–10, and is much more in harmony with practical experience than the older standard of Wolff, which demanded a much higher proportion of albuminoids. If the ration includes appreciably less than 10 to 15 lb. of coarse fodder (inclusive of 3 to 8 lb. oat or barley straw), and particularly if the concentrated foods used are of high fattening quality, the lower limits indicated above may be aimed at. With a higher proportion of coarse foods, however, the ration should be calculated to supply the maximum amounts indicated.

Further, in accordance with the general rule that small animals require in proportion to their weight rather more food than large animals of the same class, any beast weighing appreciably less than 1000 lb. should receive rather more, and any beast weighing much more than 1000 lb. rather less food than the standard ration suggests.

In making up the ration for the fattening ox the feeder should pay special attention to the palatability and water content (see p. 178) of the foods at his disposal, and also to the possible influence of the concentrated foods he proposes to use on the quality of the beef (see p. 177). He should so adjust the proportion of coarse fodder as to give the requisite bulk to the ration, whilst avoiding such large amounts as would leave the animals little capacity for consuming the more easily digestible and more effective fattening foods. If possible, the amount of roots and coarse fodder supplied should at the outset be at least sufficient to satisfy the maintenance requirements of the animal, so that the more valuable foods may be fully utilized by the animal for the production of fattening increase. According to Kellner, the maintenance requirements of lean, adult oxen may be met by a ration supplying daily per 1000 lb. live weight 15 to 21 lb. of dry matter, having a starch value of 6 lb., and containing ·6 to ·8 lb. digestible albuminoids, ·1 lb. digestible oil, and 7⅓ to 9⅓ lb. digestible carbohydrates (including fibre). These amounts are, of course, included in the fattening standard given above. The maintenance requirement will, however, steadily increase as the animal fattens, and when full maturity is attained may be fully twice as great as in the lean condition.

Growing Oxen.—The fattening of growing oxen is effected on precisely similar lines to those indicated above for the adult ox, except that, as previously pointed out, the supply of digestible albuminoids and mineral matter must be more liberal, and greater care is required in the selection of foods and general treatment of the animals. The proportion of food required to the live weight of the animal does not vary much at different ages, increasing indeed slightly during the first year. The same cannot, however, be said of the albuminoid requirements, which decrease markedly in proportion to the live weight as the animal grows. In other words, the albuminoid ratio of the food of the growing

animal may be steadily widened to the limiting value (see p. 176) of 1 : 10–12 as growth progresses. The young ox intended for beef production must be liberally fed and otherwise well cared for throughout the whole period of growth in order to ensure the greatest possible development of the frame and muscular tissues, and to secure those other qualities which characterize the 'thrifty' beast. The food, whilst being ample for the normal requirements of growth, should, however, not be of such a character as to encourage too rapid fattening.

The age at which growing oxen are fattened for beef ranges from 12 to 18 months in the case of 'baby beef' (see art. BABY BEEF) up to the verge of full growth at 3 to 4 years old. The majority of oxen fattened in Great Britain are probably disposed of at 2½ to 3½ years of age. We have very little reliable information as to the requirements of fattening oxen during the growing period, but the following standard daily rations per 1000 lb. live weight, suggested by Kellner for the *rearing* of young oxen intended for fattening, may serve as a guide:—

Age.	Live weight per head.	Total dry matter.	Digestible Nutrients.					
			Albuminoids.		Oil.	Carbohydrate + fibre.	Starch value.	Albuminoid ratio.
			Crude.	Pure.				
months.	lb.	lb.	lb.	lb.	lb.	lb.	lb.	
6–12	550	26	3·2	2·8	1·0	13·0	14·4	1 : 5½
12–18	770	26	2·6	2·2	0·5	12·5	11·2	: 6⅕
18–24	950	26	1·8	1·5	0·4	12·0	10·0	: 8¾

For fattening purposes it will probably suffice to increase the daily food supply (per 1000 lb. live weight) by about ½ lb. of digestible albuminoids, and the corresponding amount of digestible carbohydrates, &c., required to maintain the albuminoid ratios indicated. On this basis an animal in its third year would require daily per 1000 lb. live weight about 30 lb. dry matter (corresponding to about 18 to 20 lb. digestible organic matter), containing 2 lb. digestible albuminoids, ·5 lb. digestible oil, and 15 to 19 lb. digestible carbohydrates + fibre, and having a starch value of 13 to 15 lb. Such a ration is calculated to produce an increase in live weight at the average rate of about 2 lb. per 1000 lb. live weight per day, and is well in harmony with practical experience. As the animal approaches full growth the ration should, of course, be approximated more and more closely to that given above for the full-grown ox. If the weights of the individual animals at the ages specified differ appreciably from those quoted in the standards, due allowance must be made for this in calculating the allowance of food, as was explained in dealing with adult oxen. A word of warning must be uttered here, however, against too implicit reliance upon any standards in the feeding of young animals, as it is precisely in these cases where hard-and-fast rules may be most misleading, and where sound judgment and experience on the part of the feeder are most useful in regulating the food supply.

The supply of mineral matter in the food, especially of phosphoric acid and lime, is a matter of importance in the case of the growing animal. It is estimated by Kellner that the growing ox requires about 2 oz. of each of these ingredients in its daily food. As a rule, these amounts will be fully covered by the food, unless the ration consist chiefly of straw, abundance of roots and grain food, in which case the supply of lime may be rather low, and the addition of a little precipitated chalk intimately mixed with the food may be desirable.

Veal Production.—The case of the fattening of calves for veal remains to be considered.

Experience shows that the highest quality of veal can only be obtained by exclusive whole-milk feeding. The calf may be given as much milk as it will consume, but the number of meals should not exceed three, or at most four daily. If any other food is given it should be highly digestible and fairly rich in albuminoids, the aim being to form a ration which shall resemble milk in composition as closely as possible. It will further be necessary to greatly restrict the freedom of movement of the calf, and to avoid undue excitement of the animal arising from discomfort or otherwise. It may also be advisable to supply in the food a little finely ground chalk (about ½ oz. daily), in order to remedy any possible deficiency of the milk in lime salts and to check any tendency to scour.

A good fattening calf, reasonably treated, will increase in live weight at the rate of 1¾ to 2¼ lb. per day, gaining, on the average, about 1 lb. for every gallon of milk consumed. The rate of increase will, however, depend largely upon the quality of the milk.

In accordance with the principles above enunciated, the weight of food required to produce each pound of increase must also rise steadily as the fattening progresses, and will range in general from about ½ to ¾ gal. of milk during the first month to 1½ to 2 gal. at three months old.

Sheep: Mutton Production

The sheep, being closely related to the ox, requires very similar food and treatment. The food requirements of the fattening sheep are, indeed, in proportion to its weight, very similar to those of the fattening ox of corresponding stage of development. Kellner suggests practically the same fattening ration (per 1000 lb. live weight) for the two animals, viz., for full-grown sheep, 24 to 32 lb. total dry matter,

including 1·6 lb. digestible albuminoid, ·7 lb. digestible oil, and 16 lb. digestible carbohydrate (+ fibre) (see p. 179). These amounts of nutrients are, however, perhaps rather too low for the fattening sheep, since it is a matter of common observation that sheep will consume a relatively larger quantity of food than oxen. Moreover the food must provide not only for the fattening increase, but also for the growth of wool. On the other hand, sheep will make a relatively larger increase in live weight for each unit of nutrients consumed. Thus Lawes and Gilbert estimated that whereas the fattening ox required 12 to 13 lb. dry matter to produce 1 lb. of increase, the fattening sheep required only 8 to 9 lb. With sheep ranging in age from 6 months to 18 months, the daily gain with good management may range from ¼ to ½ lb. per head (or from 2½ to 5 lb. per 1000 lb. live weight) according to age, food supply, and other conditions. Lambs will indeed often fatten at an even greater rate. In applying the standards given for fattening oxen to the fattening of sheep, it will therefore be advisable to regard them rather as minimum limits, and supply the food on a slightly more liberal scale, especially in the case of growing animals. Indeed, in the latter case, the amount of food required by the growing lamb changes so rapidly, that frequent adjustment according to the judgment of the feeder is necessary. The following standards (per 1000 lb. live weight per day) suggested by Kellner for fattening lambs may serve as a guide:—

Age.	Live weight per head.	Total dry matter in ration.	Digestible Nutrients.						
			Albuminoids.		Oil.	Carbohydrate + fibre.	Starch value.	Albuminoid ratio.
			Crude.	Pure.				
months.	lb.	lb.	lb.	lb.	lb.	lb.	lb.	
6–7	66	31	4·0	3·5	0·8	16·0	17·0	1:5
7–9	88	30	3·5	3·0	0·7	15·0	16·0	:5½
9–11	110	28	3·0	2·5	0·7	14·5	15·0	:6½

The fattening ration commonly consists of roots, hay (preferably clover or other leguminous hay), and oilcake or grain. The supply of roots should be liberal, but not so excessive as to supply an undue amount of water (see p. 178).

Pigs: Pork Production

The feeding of fattening swine, although similar in principle to that of fattening oxen and sheep, offers many points of difference in detail. Owing to the greater simplicity of its digestive organs, the pig can only profitably utilize the more easily digested and less fibrous foods, but these foods it can convert into fattening increase with an efficiency unrivalled by any other animal. As in the case of oxen and sheep, the fattening increase consists almost entirely of fat, even in the case of the growing animal.

With the exception of the breeding sows, swine are now commonly fattened rapidly and disposed of at the age of 6 to 12 months. Experience teaches that in fattening such animals the best results are obtained with rations fairly rich in albuminoids and bone-forming material. The amount of food consumed may amount to as much as 40 to 45 lb. dry matter per 1000 lb. live weight at first, but the appetite falls off considerably as the fattening approaches completion, and may ultimately be not more than 25 to 30 lb. The following standard rations are suggested by Kellner, and are fairly well in accord with experience in this country:—

Age.	Live weight *per head.*	Total dry matter.	Digestible Nutrients.						
			Albuminoids.		Oil.	Carbo-hydrate + fibre.	Starch value.	Albuminoid ratio.
			Crude.	Pure.				
months.	lb.	lb.	lb.	lb.	lb.	lb.	lb.	
2–3	44	44	6·6	6·2	1·0	28·0	33·8	1:5
3–5	110	36	5·6	4·5	0·9	25·5	32·0	:6
5–6	143	32	4·4	3·5	0·7	22·5	26·5	:6¾
6–8	198	28	3·9	3·0	0·5	20·5	24·5	:7¼
9–12	286	25	3·2	2·4	0·3	18·5	19·9	:8

In the case of the full-grown animal the supply of albuminoids can be reduced still further, until the albuminoid ratio of the ration is 1 : 10–12. For such animals Kellner suggests the daily rations given on p. 182, per 1000 lb. live weight.

If the pigs are in lean condition at the outset of fattening, the food for the first 2 to 4 weeks should be rather richer in albuminoids, containing up to 4 lb. per 1000 lb. live weight. Where skim or separated milk is available, it will usually form a considerable proportion of the food.

In all cases the food of the fattening pig must be easily digestible and palatable, and in general requires more preparation in the way of cooking, &c., than the food of other animals. There is no apparent reason, however, for supplying

	Total dry matter.	Digestible.				Starch value.	Albuminoid ratio.
		Albuminoids.		Oil.	Carbo-hydrates + fibre.		
		Crude.	Pure.				
	lb.	lb.	lb.	lb.	lb.	lb.	
First period ...	33–37	3·9	3·0	0·7	26·0	27·5	1 : 9·1
Second period...	28–33	3·3	2·8	0·5	25·0	26·1	.9·3
Third period ...	24–28	2·6	2·0	0·4	19·0	19·8	: 10

all the food in the form of a porridge, as is so commonly done. Boiling and steaming should only be necessary in the case of potatoes, and very hard grain or mouldy food. Grain foods should be fed crushed, or better still, in the form of meals.

With no other animal can the quality of the meat, and more especially of the fat, be so considerably affected by the nature of the food. Owing to its tendency to produce a very soft fat, maize, which is otherwise one of the very best of pig foods, should not be used towards the completion of the fattening. The same applies to rice meal and other foods which have a softening tendency on the fat (see p. 177). Oilcakes are very rarely used. Cotton-seed meal has been used in America, but requires to be fed with great caution, and has frequently caused fatal illness. Salt is also said to be detrimental.

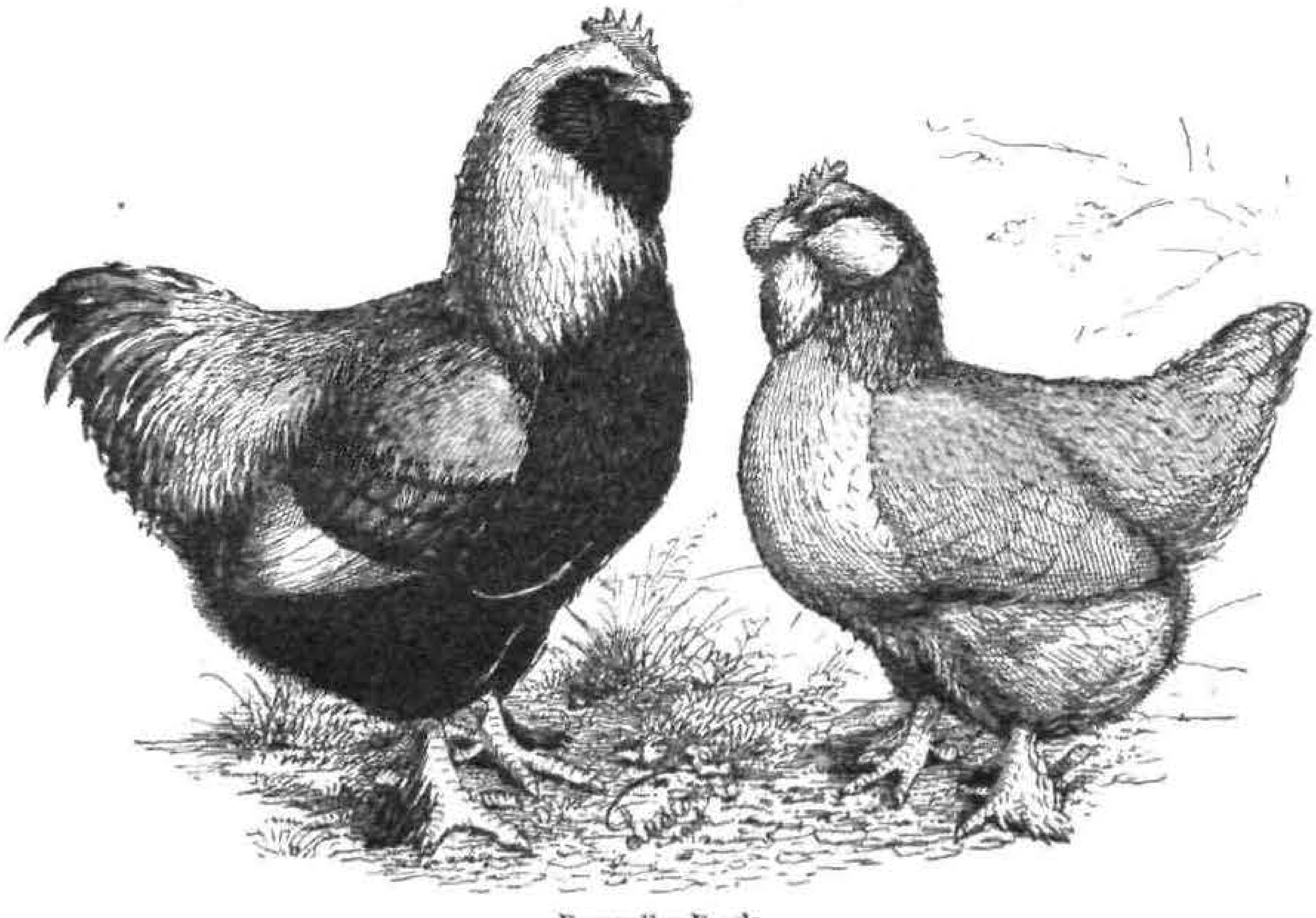
The best grain foods for producing a carcass of high quality are undoubtedly wheat middlings and bran, barley and peas. They give the best results when fed along with skim or separated milk, the finest quality of pork being secured by means of such combinations.

In conclusion, it may be remarked that no other species of animal has shown so marked a response to liberality in feeding and care in general treatment as the pig, and hence the view, which still prevails in some quarters, that pigs can be fed on anything, live and sleep anywhere and yet not suffer ill effects, is singularly unfortunate, and cannot be too strongly combated. [C. C.]

Fattening of Poultry. — See DUCKS, FOWLS, GEESE, FEEDING AND MANAGEMENT OF.

Fatty Degeneration.—The actual substitution of fat for other tissues, particularly involuntary muscular tissue, as that of the heart, is understood by the above, and not the accumulation of fat within or upon an organ, or the infiltration of fat globules between the sarcous elements. A fat beast is a common example of fatty infiltration, and is 'fat in the lean', or mottled with infiltrated fat in the meat. Fatty degeneration often leads to failure of function. It is not so common in animals as in man. Athletes when they go out of training, and racehorses and chasers, are similarly liable. [H. L.]

Faugh.—Faugh is a term applied, chiefly in Scotland, to fallow ground—ground which may either be kept bare for a time or may be cultivated for the growth of a root or forage crop.



Faverolles Fowls

Faverolles Fowl.—The Faverolles is a fairly large fowl, cocks often weighing 8 to 9 lb., and has a long, broad body, with breast carried well forward, partaking somewhat both of the

Brahma and Dorking shape, though not so upright as the former and more so than the latter. The Faverolles fowls are medium in length of leg, which are moderately feathered. The neck is short and thick, and the head is stout, with a single comb. Beneath the head are full beard and muffs, thus following the Houdan, but there is no crest. At one time the plumage varied in almost every bird, but prolonged selection has had the effect of reducing this somewhat, and the principal colours are salmon, lights and blacks. The first have black breasts, thighs, &c., with straw-coloured hackles and fluff, and a good deal of brown on the back. The Lights are silvery-white with black stripes and points; and the Blacks are self-coloured, or ought to be so.

As layers the Faverolles are very good indeed, producing a deeply tinted egg, rather small in size. They are quiet in disposition, and carry a good quantity of flesh on the breast, which flesh and the skin are white, as in nearly all the French races. The legs and feet are pinky-white. They are hardy and fatten well. [E. B.]

Favus, a disease which affects poultry. See Poultry, Diseases of.

Feal.—Pared sward or turf is known as feal. A feal dyke is a dyke composed mainly of turf.

Feather Grass (*Stipa pinnata*)

Feather Grass. — Feather Grass (*Stipa pinnata*, L.) is a hardy perennial plant with coarse herbage rejected by stock, but cultivated, nevertheless, on account of its large handsome ears. The shoots grow in a tuft, and when in ear reach a height of 4 ft. or more. The ear is especially striking and ornamental, for each of the many component spikelets bears a beard (awn) like a stalked feather, about 1 ft. long. No other grass has a beard like this.

Feather Grass is easily propagated by division —each shoot removed from a tuft is capable of producing the plant. Seed may also be used for securing the first plants. Light sandy soil is most suitable.

When the ears have to be kept in the dry state, the crop should be harvested before the feathers (*i.e.* awns) have fully developed, otherwise the ears readily allow the ornamental feathers to drop off. In order to increase the ornamental effect, dyes of various bright colours may be applied, and in this dyed state the ears are often sold in the markets. [A. N. M'A.]

Feathers. See Nitrogenous Organic Manures.

February, Calendar of Farm Operations for.—

1. Southern Britain

Arable Farm.—*Corn Crops.*—Spring wheat, beans, black oats, and barley are sown during this month. Ploughing for spring crops proceeds. Fallow land should be ploughed to let any frost mellow and pulverize it.

Forage Crops.—Cabbage seed is sown now in beds for transplanting out later.

Roots.—Theoretically, mangolds are at their best ripeness now for feeding purposes. The land for the coming crop should be in balks by this time, if the crop is to be grown on balks and not 'on the flat', and the manure carted on and covered in by splitting the balks.

Special Crops.—Hardy early peas can be sown now, also gorse or furze for fodder, and canary seed. The land is being prepared for parsnips, carrots, and sainfoin.

Grass Lands.—Water meadows which have been flooded at intervals should be beginning to show signs of growth. Dung can still be applied to grass lands. It should not be later, and ought to have been done earlier. Chain-harrowing of pastures and grass lands can be started during this month to level the molehills, tear up moss, &c.

Meadows intended for hay may be closed now, and harrowed and rolled.

Manuring.—Farmyard manure can be carted on to the root land.

Gypsum should be applied to such land as needs it, in preparation for sainfoin.

Stock Farm.—*Horses.*—The weather becomes more open, and the days become longer in February, so the amount of the horses' work increases; consequently their rations should be increased. Mangolds are in good condition for feeding now, but should only be fed sparingly.

Colts that are of age generally get their first taste of work in the plough during this month.

Dairying.—Cows are still housed at night, and during the day also in most districts, although it is a good plan to turn them out for a few hours daily.

They should be milking well, and it pays

better to sell milk or make butter than to make cheese at this period of the year. Silage is useful now and mangolds are at their best.

The calves, if heifers, are generally reared, but are sold if steers. They may be kept and fattened for veal.

While the cows are housed, it is a capital plan to currycomb them frequently.

Store Cattle.—Fattening of bullocks proceeds, and beasts are sold as they become fit for the butcher.

Steer calves can be fed on skim milk and meal to fatten for veal.

Store cattle should be very carefully attended to, as there is often a prevalence of very cold and bitter winds at this time, also ringworm begins to show itself.

Sheep.—The ewe flock occupies attention, as lambing is in full swing. The ewes should be afforded protection for lambing in sheds. Those animals set aside for fattening are being fed in folds or on the pastures with oilcake, hay, and roots. They are sold off as they become fat and ready for the butcher.

Lambs should be castrated when about twelve days old, but a fine afternoon should be chosen. When the lambs are old enough to feed themselves at all, they can be allowed on to some soft crop, such as rape, turnips, or kail. Silage and swedes come in useful for the ewes at this period.

Pigs.—Sows which farrow at the end of the month are carefully watched. Store pigs that are ready for fattening should be put on to richer food.

Poultry.—Eggs should become more plentiful now, and special efforts should be made to hatch out early broods. Incubators should be used if setting hens are not available. Guinea-fowls are now in season, and are valuable as table birds, as 'game' is not obtainable. It is important to see that the cocks are healthy and well fed, especially at this season of the year.

[P. M'C.]

2. NORTHERN BRITAIN

During this month all arrears of lea ploughing should be finished without delay. There is usually a good deal of frost in this month, but the rainfall is seldom very heavy, and it occasionally happens that for a week or two the land may be in nice working condition. In early districts and on open-bottomed land, when such happens, oats may be sown with freedom; and if any wheat is still to sow, it should be committed to the soil at once. Oats sown at this date on free land in good condition almost invariably do well, and it seldom happens that they are hurt by frost. When the weather is suitable, the cross ploughing of land for green crops should be pushed forward; and if hard frost sets in, dung should be carted out, and put in heaps ready to be put in the drill. The saving effected by having dung near the ends of the drills when it is to be so used is very great, and, when weather permits, as much of it as possible should be moved to this position. Where cabbages are grown, either for consumption by lambs or for table use, some planting should always be done this month. When the land is moderately dry, and there is even considerable frost at night, is a good time in which to do the drilling, as if the land is harrowed during the afternoon when softened by the sun, it rarely freezes sufficiently hard to stop the drill plough next day. If this is attended to, it is wonderful how much land may be drilled in weather when ordinary ploughing is scarcely possible. What has been said with regard to cabbages also applies to beans and peas, both of which always do best when sown early, and neither of which scarcely ever suffer from frost in spring.

In the early potato-growing districts planting should begin now, and be carried on during all dry periods, and in the later districts seed may be yet put in boxes to save the seed from premature sprouting.

Straw becomes less palatable as spring approaches, and a portion of what has hitherto been supplied to stock of all kinds should be withdrawn, and an equivalent of hay given in its place. The houses in which the calves are to be tied up should be thoroughly cleaned out, and everything put in order before they begin to come. In dry districts which are early and well sheltered, lambs begin to be dropped about the end of the month. Where sufficient care is devoted to them, and ample provision in the shape of sheds exists for their protection, few classes of stock pay better than early lambs, but they should never be attempted on heavy land, in exposed situations, or where ample shelter is not available. In cheesemaking districts, where large numbers of pigs are wanted in spring and early summer, the first of the sows should begin to farrow about the end of this month, so that the pigs may be six or eight weeks old when cheesemaking begins. [J. S.]

February, Calendar of Garden Operations for.—

1. SOUTHERN BRITAIN

Work in the garden this month should be chiefly the preparation of the ground by digging and manuring; the pruning of fruit trees and bushes, if not already done; and preparation for sowing for early crops of such vegetables as onions, parsnips, carrots, broad beans, brussels sprouts, early cabbage, cauliflower, leeks, lettuce, parsley, peas, radishes, savoys, and an early variety of turnip. Potatoes may also be planted on a warm, sunny border, where, should frost occur, they can be protected with a covering of litter after the tops are above-ground. A snatched crop of early potatoes is always worth the extra trouble. Planting operations in the orchard and fruit garden may be continued if from any cause the work could not be performed in October, the best month for transplanting fruit trees. The stems of established trees should be examined, and if they show the presence of blight or other disease they should be washed with an insecticide; indeed, it is not too soon to spray them as a preventive against the attacks of fungoid and insect pests. If strawberries have not been attended to, new plantations may be made. It does not pay to keep the plants after the second year's crop.

Seeds of tender annuals which require to be raised under glass should now be sown. A sowing of celery may be made at the same time. Mulch the borders in the shrubbery and flower garden with well-rotted stable manure, putting on a layer of about 3 in. Should there be an objection to the manure being left exposed, it may be covered with a thin layer of soil, which is preferable to digging it in, an operation which often does harm by mutilation of the roots of the plants in the border. The propagation of plants for bedding, such as fuchsias, pelargoniums, heliotropes, and lobelia, should now be proceeded with, and it is not too early to commence repotting such plants as will require fresh soil or more root space during the year. The laying of new turf, or the dressing of old with a mixture of fine soil and guano, may be undertaken now. Seeds of such popular greenhouse plants as primulas, cyclamens, gloxinias, begonias, torenias, and cockcombs may be sown, transplanting the seedlings as soon as they are large enough to be handled. Dahlias, scarlet lobelias, and tuberous begonias should be started in warmth if a stock of young plants is required, the young shoots which develop being used as cuttings, placing them in a warm, close frame to root, afterwards hardening them off. In the forcing department, rhubarb, seakale, and asparagus will require attention. Directions for their treatment will be found under their respective headings. Vines may be started by keeping the house close and moist, and following the directions given with regard to the stopping and thinning of the shoots. Peaches and nectarines under glass also will require attention, disbudding and stopping the strongest growths in order to reduce their vigour and equalize the flow of sap. A sharp lookout should be kept for insect pests of all kinds, fumigation with tobacco smoke at this time of year preventing serious attacks later on. [W. W.]

2. Northern Britain

When the weather is favourable, continue to push on all heavy work in the way of trenching and digging, or alterations of grounds. The transplanting of deciduous trees and shrubs, whether for ornament or utility, should if possible be finished by the end of the month.

Preparations must now be made towards the cropping of the garden for the season. In warm and light soils a sowing of an approved variety of early peas, also broad beans, parsnips, and parsley, may be made when the soil is in a suitable condition. Early potatoes which have been started in boxes may likewise be planted.

The sprouting and planting of potatoes for an early crop, which is now such an important feature in farming in certain favoured districts, is a very old practice in gardening, though necessarily in a limited degree. There is no reason whatever why it should not be more fully practised by those who desire an early supply, as most gardens have some sheltered spot suitable for the purpose. Even for later plantings in the garden the sprouting of the 'sets' will in most cases repay the little extra labour.

Where means are available, a small sowing of cauliflower—of the early dwarf type—brussels sprouts, and early cabbages should be made in boxes or frames for early work. These must not be unduly forced, but brought on gradually. Sow thinly, and when showing the rough leaf prick out carefully in a frame, or place where they can be sheltered from severe weather until strong enough for planting out.

Onions may be treated in the same manner, and in gardens where there is some difficulty in raising a crop, when sown in the ordinary way out-of-doors, this method will be found a satisfactory one. Leeks can also be treated in a similar manner when required for early use or exhibition purposes.

Plants which have been wintering in frames will now require close attention as to airing and shading. After the dull winter months many sorts will be somewhat tender and weak, and as the increasing light and heat induces new growth, undue exposure to cold winds or strong sunshine is more frequently fatal at this time than during any month of the year, hence the necessity for extra precautions. While this applies generally to all plants, it is especially so in the case of calceolarias, pentstemons, antirrhinums, pansies, and cauliflowers. Carnations, pinks, and bedding violas are less susceptible to changes, but all require attention against extremes.

Where it is desired to raise pentstemons, antirrhinums, pansies, &c., for summer display from seeds, these should be sown in pans or boxes where a frame and hotbed is available. If no warm frame or greenhouse is available, defer the sowing of these until later.

Tomatoes sown early in January will now be ready for pricking off into small pots. Use a fine light mixture of leaf mould, loam, and sand, and keep them growing in a light airy position at an average temperature of 60 degrees. Keep up a supply of rhubarb in the forcing house as necessity demands. Where peaches are cultivated under glass, in ordinary conditions the buds will be swelling fast, therefore the work of pruning, cleaning, and training, if not already accomplished, must be seen to without delay. Thin out all worn-out and weak shoots. Unless where more young wood is required to refurnish bare spaces in the trees, do not shorten the fruit-bearing shoots. Avoid the common evil of overcrowding. A fair distance to train the young shoots is 4 in. apart; that should be the minimum. See that the borders are well watered, as there is nothing more fatal to success in the cultivation of stone fruits than dryness at the root or in the atmosphere during the growing season. It is assumed that the trees are not being unnaturally forced, therefore keep the house fresh and airy. As the trees come into bloom, care must be taken to avoid chilling draughts; but do not keep the atmosphere close and stuffy, admit fresh air freely in mild weather, and keep a little on at all times.

In regard to vines, as the buds begin to swell syringe with soft water twice a day, and keep the house slightly warmer. [J. Wh.]

Fecundity and Fertility.—It is usual to apply these two terms to two distinct qualities

By fertility is meant the degree of productiveness, the quality of producing a large or a small number of offspring. Thus we say that the rabbit has a much greater fertility than the horse. By fecundity is meant the demonstrated capability of bearing offspring. It is the opposite of sterility. 'Fertility', Matthews Duncan wrote, 'implies fecundity, and also introduces the idea of number of progeny; while fecundity simply indicates the quality without any superadded notion of quantity.' Professor P. G. Tait defined the terms as follows: 'By fecundity at a given age, we mean the probability that, during the lapse of one year of married life at that age, pregnancy producing a living child will ensue.' 'By fertility at any age we mean the number of children which a married woman of that age is likely to have during the rest of her life, or some numerical multiple of it.' Less strictly, when we say that Breed A has a greater fecundity than Breed B, we mean that the proportional number of impregnated females that bear offspring (that are not sterile) is greater in A than in B. From a hundred mares that have been served a certain number of foals are *possible*, and the number would indicate the gross theoretical fertility in the time; but the ratio of the number of actual foals to this possible total would indicate the degree of fecundity. A flock of goats yielded 31 per cent of kids one year, and 156 per cent another year—a striking difference in fecundity, but not necessarily in fertility. It is also useful to distinguish between gross fertility and net fertility, the former taking account of every birth, the latter of those offspring that are viable and survive.

GENERAL BIOLOGICAL ASPECT.—Before we consider fertility in relation to farm animals, we may point out that the quality is variable for any species, that the degree of it is transmissible, that it is correlated with other characters, such as general constitutional vigour, and that it is of great importance in the struggle for existence. How fertile a type may be depends in part upon the nature of its reproductive arrangements; thus a mammal that carries its young in the uterus before birth and suckles them after birth cannot by any amount of variation and selection produce thousands of offspring in a season; a bird with large eggs, laden with immense reserves of yolk and enclosed in hard shells, cannot be the mother of millions as a codfish might be. Where the reproduction is relatively inexpensive, *e.g.* in being *oviparous* not *viviparous*, it is likely to be more prolific. The codfish is said to be capable of producing nine millions of eggs in a year, and the conger eel fifteen millions, and even if these figures require pruning (they certainly require revision) there is no doubt as to the numbers being enormously greater than anyone can clearly imagine. They stand in sharp contrast to a case like that of the fulmar petrel of the mid-Pacific, which lays but one egg yearly. Yet the fulmar petrel is very successful and abundant within the region it frequents, and we are thus led to the Darwinian conclusion that the rate of reproduction has been regulated in the course of many generations in relation to the chances of death. It need hardly be said that the regulation can only work within the limits of the variations supplied to it, and that for lack of adequate fertility many species have become extinct.

The most elaborate discussion of fertility is that given by Herbert Spencer in his Principles of Biology, but some of his deductions require to be rigorously tested by statistics and experiment. A very effective and well-substantiated part of the argument is that which shows the coincidence between high nutrition and a high degree of fertility, and here the author gave a wealth of evidence. Justly, as it seems to us, he pointed out in this connection that the enormous fertility of animal parasites, which combine superabundant nutrition with greatly diminished expenditure, is the necessary correlative of such a state of nutrition and expenditure, and not merely an acquired adaptation to their peculiar difficulties of survival. The most important general conclusion was expressed in the formula—Individuation and Genesis vary inversely. That is to say, the more highly evolved organisms tend to be less fertile, advancing evolution must be accompanied by declining fertility.

COMPARATIVE FERTILITY OF VARIOUS TYPES.—The elephant is a well-known instance of a low degree of fertility; it is said to take at least twenty-four years to become mature, it carries its young for twenty months, and it brings forth one at a time. It is said to go on breeding at intervals till it is ninety—it may be more than a centenarian—and yet after all it produces only six offspring. The horse takes about four years to become mature, it carries its young for eleven months, it usually brings forth only one at a time. Similarly, such diverse types as man, monkeys, bats, whales, cattle, *usually* bear one offspring at a time, and after a prolonged gestation. But when we pass to mammals of a lower degree we find a great contrast. 'Under favourable conditions the mouse, rat, rabbit, and guinea pig are practically always with young. In all of these a new copulation and fertilization, *i.e.* a new gestation, follows at once, with only a very slight interval, upon the birth. All of these forms, as a rule, and under proper conditions, are ready for a new pregnancy within at most a few hours after the cessation of the old one. An experienced rabbit-breeder informed me that a doe-rabbit may sometimes bear as many as eleven litters in a year' (Dr. John Beard, Span of Gestation, 1897). A young rabbit may have young when it is six to eight months old; it brings forth five to eight at a time; it often has six litters in a year; a pair might be the ancestors of twenty millions in five years.

It is not merely the frequent succession of pregnancies, but the number of offspring at each birth, that makes the fertility of these lower mammals so great. The rabbit often has five to eight young, the pig may have eight to fourteen, and that does not indicate the gross fertility, fourteen embryos having been found at one time in the rabbit's uterus, and as many as twenty in the pig. The largest known number is in the opossum (Didelphys), in which Selenka counted

twenty-seven. As there are never more than fifteen teats in the opossum and sixteen in the pig, it is evident that even if the twenty-seven and twenty embryos had survived to the birth period they could not have been suckled, since each suckling has a teat to itself.

DIFFERENT DEGREES OF FECUNDITY. — It is difficult to arrive at satisfactory conclusions as to comparative fecundity. In regard to wild animals statistics are lacking, and in regard to most domesticated animals there are so many conditions, many of them very artificial, to be taken account of, that the results of statistics require to be treated very cautiously. The temporary sterility of a female may lead the owner never to try her again; apparent infecundity may be due to quite artificial peculiarities, and may disappear when the animal changes hands; some of the statistics count only the viable offspring, others count in the abortions as well, and so on. We quote a few statistics from Cornevin's well-known Traité de Zootechnie générale (Paris, 1891). From an average hundred mares in central Europe, fifty-one to fifty-two foals may be expected; the Herd Book of the Experimental Farm at Lyon showed for a period of eight years an average of seventy-five calves from one hundred cows; for sheep the degree of fecundity is higher still, and 82 per cent seems not uncommon. In contrast to such a high figure as 82 per cent, we have to recall a case like that of the elephant, which does not breed in captivity, thus adding infecundity to its naturally low degree of fertility.

FERTILITY AS A HERITABLE CHARACTER. — When we compare the productivity of tame rabbits and wild rabbits, of pig and boar, of the dog and wolf, and so on, we are led to the conclusion that certain domesticated forms are much more prolific than their wild relatives. This is notably the case with ducks and poultry. It may be due in part to the direct influence of the abundant nutrition secured in the domestic environment; it is in some cases due to the continued selection of the more fertile. To take a contrasted pair of cases, the half-domesticated ferret is said to be much more prolific than the polecat, of which it is simply an albino variety, and this is probably a direct result of the artificial conditions; on the other hand, it is quite certain that the fertility of pigs, which is very great to start with in the wild state, has been increased during domestication by selecting the more fertile for breeding from. It is certain that it can be increased still more by the same method. Thus Messrs. Rommel and Philipps have shown in regard to Poland China hogs: (1) that there has been an increase of 48 per cent in the size of the litter in the twenty years between 1882 and 1902, and (2) that the size of the litter is a character definitely transmitted from mother to daughter. 'It would appear proved that, by judicious selection for breeding purposes of sows from large litters, the average for the breed may be increased.'

Buffon pointed out that domestic animals breed oftener and produce more young than their wild relatives, and that they sometimes breed earlier. Darwin was also emphatic in pointing out that increased fertility has followed domestication. 'With hardly an exception, our domesticated animals, which have long been habituated to a regular and copious supply of food, without the labour of searching for it, are more fertile than corresponding wild animals.' . . . 'The wild sow is remarkably prolific, for she often breeds twice in the year, and produces from four to eight, and sometimes even twelve young at a birth; but the domestic sow regularly breeds twice a year, and would breed oftener if permitted; and a sow that produces less than eight at a birth is worth little, and the sooner she is fattened for the butcher the better.' . . . 'Birds offer still better evidence of increased fertility from domestication: the hen of the wild *Gallus bankiva* lays from six to ten eggs, a number which would be thought nothing of with the domestic hen. The wild duck lays from five to ten eggs; the tame one in the course of the year from eighty to one hundred' (*Animals* and Plants under Domestication, vol. ii, p. 111). Of much importance is Darwin's conclusion: 'In some cases, as with the pig, rabbit, &c., and with those plants that are valued for their seed, the direct selection of the more fertile individuals has probably much increased their fertility; and in all cases this may have occurred indirectly, from the better chance of the more numerous offspring produced by the more fertile individuals having survived. But with cats, ferrets, and dogs, and with plants like carrots, cabbages, and asparagus, which are not valued for their prolificacy, selection can have played only a subordinate part; and their increased fertility must be attributed to the more favourable conditions of life under which they have long existed.'

Very important work has been done by Professor Karl Pearson and others who have investigated heredity by statistical methods. Thus, taking the subtle quality of fecundity in thoroughbred racehorses, Pearson and Bramley-Moore have shown that it is inherited between dam and daughter, and also through the male side. It has also been shown (*e.g.* as regards man) that fertility is a heritable quality. In other words, exact proof has been given of what might have been inferred on presumptive evidence from cases, like those of poultry, where domesticated forms have attained to a remarkable degree of fertility. Many breeders have noticed the heritability of a tendency to bear twins, and this would probably be even more obvious than it is if it were not for the prejudice that many have against breeding from twins, which are sometimes, because they are twins, below the average in vigour. In this connection we may recall the fact that the various domesticated animals which are normally uniparous differ greatly in their tendency to produce twins. A twin birth may be expected for mares about once in a thousand births, in cattle about once in eighty births.

INHERITANCE OF FERTILITY IN SHEEP.—As a special case of the inheritance of *fertility*, we may note that twins in sheep are said to be more prolific than those born singly. Cornevin quotes Bernardin's observations extending over seven years, that ewes which were the twin-

sisters of males compared with the general herd at Rambouillet as follows: Number impregnated, 87 per cent, as against 83·1; number with twin gestations, 12 per cent, as against 10·7; number of lambs resulting, 98 per cent, as against 92,—an interesting comparison, which should be extended, with every precaution to secure accuracy. Dr. Marshall notes that the progeny of a very fertile Border Leicester ewe (which consistently bore twins or triplets, and on two occasions four) always produced either twins or triplets. It is often the case that twins are inferior in development through lack of sufficient nourishment. They are therefore often neglected for purposes of tupping—which means, other things being equal, neglecting the more prolific. By breeding from twin-bred rams and ewes for some years, Mr. H. C. Stephens of Cholderton, Salisbury, has attained in a flock of Hampshire Down sheep the remarkable lambing record of 200 lambs per 100 ewes. As he says, 'The mistaken practice of neglecting twin-bred rams greatly reduces natural fertility'.

CONDITIONS AFFECTING FERTILITY AND FECUNDITY.—*It may be safely said that feeding* often affects fertility and sometimes affects fecundity, but it is a regrettable fact that comparatively few exact experiments have been made on the subject. In the beehive, unfertilized eggs develop into drones, and fertilized eggs develop into workers or queens, the determining factor in the last case—decisive between non-fecundity and great fertility—is the quantity and quality of the food. Within the first eight days of larval life, the addition of a little food (particularly, it appears, if the fatty constituents are increased) will determine the striking structural and functional differences between worker and queen. Up to a certain point, the nurse bees can determine the future destiny of their charge by changing the diet, and this in some cases is certainly done, for a worker grub may be reared into a queen bee. This case may seem remote from the poultry yard or the breeding pen, but it is a case that has been carefully studied, and it illustrates the influence of nutrition on fecundity.

The number of lambs in a season is said to be correlated with the nutritive conditions; when these are good there are more lambs. There are more twins and fewer failures. Cornevin states that he took two similar lots of guinea pigs and kept them under similar conditions, except that the one lot was fed with abundant green food, whereas the others got a sparse supply of crumbs and maize, with the result that the first lot had more than twice as many offspring as the second. In regard to the fecundity of stallions, the same authority states that an abundant supply of green food has a very beneficial effect. It must, of course, be noted that a mere increase in the quantity of food may be of little moment; instead of improving either fertility or fecundity, it may produce fat and nothing more. The quality of the food counts for something, and there may be too much of a good thing. 'Every year', Cornevin says, 'we have before us at the shows, specimens of the finest breeds of sheep and pigs, which, though ideals of good build, assimilative power, and fattening capacity, are—sterile.'

Apart from 'flushing', which means extra feeding about the tupping time, there are data going to show that the degree of fertility may be raised by generous diet. Thus in a flock of Blackfaces, a breed in which the degree of fertility is usually relatively low, the percentage of lambs per ewes was raised to 160 when 'the ewes were fed upon good grass, hay, and stubble, from tupping time until the beginning of the new year. They were then supplied with clover hay and turnips, followed by swedes at the approach of the lambing time.'

INFLUENCE OF 'FLUSHING' ON SHEEP.—In regard to sheep, it seems certain that some sort of 'flushing', or extra feeding immediately preceding and during tupping, is likely to result in an increase of fertility at lambing. Dr. F. H. A. Marshall gives an account of three cases in which the percentages of lambs were 191·5, 193·75, and 196. In the second of these cases (which is most conveniently quoted) the ewes, which were half-bred (Cheviot-Border Leicester), 'were given Bombay cake, bruised barley, a little linseed cake, as well as turnips and cabbages, during tupping time. Previous to tupping, they were fed only upon grass. Some turnips were allowed throughout pregnancy. The rams (which were Border Leicester and Oxford Down) were treated in the same way as the ewes. Triplets were produced by 13·5 per cent of the ewes. None aborted or were barren. The ewes were all three-shear.'

In another striking instance the percentage of lambs per ewes was 198. 'The flock was fed upon a full supply of turnips for three weeks before tupping and a month during tupping, and upon a smaller supply of turnips on grass fields until one month before lambing. After lambing the sheep were fed upon cut hay, dried grains, oats, and turnips. Fourteen per cent of the ewes had triplets. The percentage of barren ewes was 1·75. No ewes aborted. The ages of the ewes are not recorded.'

There are facts which suggest that 'flushing' may be overdone, that an abrupt transition from 'flushing' to a bare sustenance diet may be very prejudicial, especially in the succeeding season, and that if the custom of 'flushing' is begun it may have to be gone on with; but the general result of Dr. Marshall's careful enquiry is that extra feeding at about tupping time increases the crop of lambs and also improves the fecundity. It is interesting to enquire further how these results are brought about, and we venture to quote once more from Dr. Marshall's paper—one of the few *scientific* documents dealing with this very important subject. He says: 'There is abundant evidence that flushing hastens forward the tupping time. It has been recently shown that 'heat' in animals is probably brought about through the action of an internal secretion elaborated by the ovaries. It would appear, therefore, that the artificial feeding exercises a stimulating influence over the secretory activity of the ovaries, while at the same time causing the Graafian follicles (or ovarian vesicles which contain the ova) to reach maturity more rapidly,

and a larger number to discharge during the early 'heat' periods of the tupping season.'

The fertility of a flock may be affected not only by feeding but by other environmental influences, such as weather. Bad weather during the tupping may bring the percentage of twins below the average; bad weather during pregnancy may increase the number of abortions; and the storms of one season may influence the births of the next. Some facts are available which suggest that transportation to a different climate may affect the fertility, but climate includes a complex of factors which require to be analysed out. The peacock is remarkable as an example of a domesticated bird which, in spite of abundant feeding, is less fertile in Britain than in its native country—India. It has also been observed that a change *to a new climate may greatly prejudice fecundity*, both as to susceptibility to impregnation and as to capacity for normal gestation. In this connection the arts. on ABORTION and ACCLIMATIZATION should be consulted. Another factor, which may influence both fecundity and fertility, is close inbreeding, which may be prejudicial, whether directly or indirectly it is difficult to say. See BREEDING.

AGE IN RELATION TO FERTILITY AND FECUNDITY.—Another factor which affects both fertility and fecundity is age. For the young mare, the young donkey, the young Durham heifer, the young sow, and so on, it has often been remarked that the first servings are apt to have no result. In other words, the fecundity increases up to a certain age, and then decreases again. But the same is sometimes demonstrable in regard to fertility, the size of the sow's litter is usually below the average the first time. The roedeer (*Capreolus caprea*) usually produces two fawns at a birth, but not the first time. In a flock of sheep all lambing for the first time, there are likely to be far fewer twins than in a flock whose members have lambed before. Statistics quoted by Cornevin in reference to more than 10,000 mares show that fecundity increases up to twelve years and then decreases rapidly. Out of a thousand mares twenty years old, 226 were fecund; out of a thousand, twenty-five years old, 22 were fecund. Cornevin also gives statistics for sheep, which indicate that the fecundity increases up to four years of age and then decreases. In regard to man, the important law has been deduced from statistics that 'fecundity at various ages is proportional to the number of years a woman's age is under fifty', or, more strictly, 'the average number of children per annum born to a mass of women of any one age is proportional to the difference between that age and fifty'.

TIME OF SERVING.—A subtle factor in fertility seems to be the time of impregnation. The reproductive organs have their rhythms or tides, and it is well known that if the tide be lost, the serving may be futile. More than that, however, the number of offspring (in cases where there are often several) is affected by the time of serving. Thus ewes served near the commencement of the tupping season have usually more lambs than those which are served at the end of tupping. The practical corollary (if many lambs are desired) is to get the ewes tupped early.

In conclusion, we would emphatically point out that relatively little is securely known in regard to fertility and fecundity in farm animals. Every year many experiments are made which should throw light upon the difficult problem of the factors determining the two qualities of fertility and fecundity. Some of these experiments are at random, others are very deliberate; in both cases it is very desirable that the conditions and results should be recorded with scrupulous accuracy and in as objective a fashion as possible, that is, without any mingling of observation and inference. [J. A. T.]

Feed.—Though synonymous with the word 'ration', the term 'feed' is more commonly applied to the quantity of oats or grain given to animals—especially to horses—at one time. A feed of corn weighs about 4½ lb.

Feeding of Animals.—See CATTLE, FEEDING AND MANAGEMENT OF; STORE CATTLE; COWS, FEEDING AND MANAGEMENT OF DAIRY; FATTENING OF FARM ANIMALS; HORSES, POULTRY, AND SHEEP, FEEDING AND MANAGEMENT OF, &c.

Feedingstuffs, Classification of.—The principal constituents of value in feedingstuffs are: (1) The fats or oils; (2) the nitrogenous matters, consisting mainly of the albuminoids, with a certain amount of amides, &c.; (3) the carbohydrates, comprising principally starch, sugar, and cellulose, together with gum, mucilage, pectin, vegetable acids, &c.; (4) mineral matters or ash constituents, of which phosphoric acid, lime, and potash are the principal ones of value.

Feedingstuffs may be divided into classes in three different ways:—

I. According to the botanical nature of the materials from which they are derived—for instance, whether these be oilseeds, leguminous crops, cereals, or root crops.

II. According to the purposes for which they are generally used—*e.g.* as concentrated foods (cakes), as meals (cereal grains), as dry bulky foods (straw and hay), or as succulent green foods (roots, cabbage, grass, &c.).

III. According to the constituents which they contain in greatest prominence—*e.g.* oil, albuminous matters, starch, sugar, fibre (cellulose), &c.

These divisions are by no means absolute ones, but frequently run one into the other, and it is but seldom that a feedingstuff can be considered as belonging to one class only.

Under feedingstuffs obtained from oilseeds may be grouped cotton cake (decorticated and undecorticated), linseed cake, rape cake, palmnut cake, cocoanut cake, and earthnut cake, with sundry others of only occasional occurrence, such as sunflower cake, nigerseed cake, &c.

Leguminous feedingstuffs would include beans, peas, lentils, malt, dried grains, and possibly bran, also lucerne hay, sainfoin hay, and clover hay. Cereals would comprise wheat, barley, oats, rye, rice, and maize, with their different straws; also grass and meadow hay. Under root crops

would come turnips, swedes, mangels, beet, kohl-rabi, potatoes, carrots, &c.

If divided according to the purposes they serve generally, among concentrated foods would be the whole class known as oilcakes or feeding cakes, including the various compound feeding cakes; also nitrogenous foods like beans, peas, lentils, dried grains, and malt.

Under meals would come wheat, barley, oats, rice, and maize, together with different milling products of wheat, such as bran, pollards, sharps, &c.

Bulky dry foods would comprise the different kinds of hay and straw; while succulent green foods would include all classes of root crops, grass, mustard, rape, tares (vetches), cabbage, &c.

The third method of division, that according to the constituents found present in greatest prominence, is the one that can be best followed here in further detail.

1. *Foods valuable for the oil they contain.*—Of these there are cotton cake (the decorticated containing 8 to 10 per cent of oil, and the undecorticated 5 per cent), linseed cake (9 to 13 per cent), rape cake (9 to 10 per cent), earthnut cake (8 per cent), palmnut cake and cocoanut cake (10 to 11 per cent). Besides these, there come on the market from time to time cakes which are the residue left after expressing the oil from many other oilseeds, such as niger-seed, til or sesamum, sunflower, &c.

Oils have, however, very different feeding values, and it is a great mistake to class them all together. There are foods, for instance, like rice meal, which may contain up to 13 per cent of oil, but which are rightly not classed among foods valuable for their oil, the oil having, as in the case of rice or maize, but little feeding value. Very different is the case with linseed oil, the value of which, as shown in a linseed cake rich in oil as compared with one comparatively low in oil, is well recognized. In considering compound feeding cakes, therefore, it is more material to know what the oil is derived from than the actual percentage that is present.

2. *Foods valuable for the oil and albuminous matters they contain.*—The large class of oilcakes just mentioned would come under this head, for, though chiefly valued for their oil, they frequently contain albuminoids in high amount. The greater extent to which the oil is expressed the higher will necessarily be the albuminoids; accordingly a hard-pressed linseed cake, such as are many of the American ones, will be proportionately richer in albuminoids. Linseed cake will contain from 26 to 30 per cent of albuminoids, undecorticated cotton cake (Egyptian seed) from 21 to 24 per cent, undecorticated cotton cake (Bombay seed) 18 to 19 per cent, while decorticated cotton cake and earthnut cake are the richest of all foods in this respect, and will contain from 40 to 45 per cent of albuminoids. The tendency of late with decorticated cotton cake has been to get it lower in oil and higher in albuminoids than was formerly the case. Palmnut cake and cocoanut cake are not so nitrogenous, having only about 18 to 20 per cent of albuminoids, whilst rape cake will have from 28 to 30 per cent. Compound feeding cakes may also come under this heading, according to their composition and the nature of the materials from which their constituents are derived.

3. *Foods valuable for the albuminoids and the carbohydrates they contain.* — Prominent under this heading come beans and peas, also the less generally used lentils. Malt, dried grains, and, to some extent, bran, may also be included. Beans and peas are typical of this class, and they will contain from 20 to 24 per cent of albuminoids, with from 50 to 55 per cent of digestible carbohydrates, mainly starchy bodies. Malt sproutings or 'culms' are more highly nitrogenous than malt itself, and may have 20 to 22 per cent of albuminoids, with 45 per cent or so of starchy bodies, malt itself containing less nitrogen and more starch. Dried grains contain about 20 per cent of albuminoids. Bran has from 12 to 15 per cent of albuminoids, with 55 to 60 per cent of starchy bodies.

4. *Foods valuable only for the soluble carbohydrates they contain.*—This class includes materials used for sweetening purposes, such as sugar and molasses, and with these may be put locust beans, which contain about 50 per cent of cane sugar.

5. *Foods valuable mainly for the starchy bodies they contain.* — Under this head come the various cereal grains—wheat, barley, oats, rye, maize, rice, these containing from 50 per cent (rice) to 70 per cent (maize) of starchy bodies. The offals of wheat (sharps, pollards, middlings, &c.) might also be reckoned as coming in this class, though they are somewhat more nitrogenous than wheat itself. All the above are used principally for mixing with the more concentrated foods of Classes 1 and 2, and for thus providing a suitable mixed diet containing oil, albuminoids, and starchy matters. They comprise mainly the food grains grown on the farm, and thus available for home consumption. Maize and rice, however, are imported and purchased starchy foods.

Of different nature, but coming within the same category, are the root crops of the farm—turnips, swedes, mangels, beet, potatoes, and kohl-rabi. They are useful alike for the sugar and easily digested carbohydrates which they contain and for their succulent properties, as well as because of the small amount of indigestible fibre in them. In turnips and swedes the sugar is mainly present as glucose or grape sugar (5 to 7 per cent), in mangels and beet it is principally cane sugar (8 to 10 per cent). Potatoes are mainly starch-containing, so far as the solid matters in them are concerned.

6. *Foods valuable mainly for their fibre.*—The list of these comprises the different classes of hay and the cereal straws already noted.

7. *Foods valuable mainly for their succulent properties.* — This class includes grass (green), silage, green crops such as mustard, rape, tares (vetches), trifolium (green), clover (green), cabbage, kale, prickly comfrey. Also under it must be reckoned the root crops noted under Class 5, and wet brewers' grains, which are used principally as a succulent food for milking cows.

[J. A. V.]

Feedingstuffs, Valuation of.—While the valuation of manures is a comparatively simple matter, depending mainly on the respective percentages in which the several recognized fertilizing constituents (the nitrogen, phosphoric acid, and potash) are present, and on the current market prices of the same, the valuation of feedingstuffs is a matter that presents many difficulties. It is known fairly well which are the constituents that determine the value of feeding materials, and also what are, generally speaking, the functions which these fulfil, but with rare exceptions does it happen that a feeding material is comprised of one such constituent only. A linseed cake, for example, is not valuable merely for the linseed oil it contains, but it has also albuminous matters in large amount, and many valuable carbohydrates, as well as mineral matter not without importance. It is not possible, therefore, to take out, as it were, one single constituent, such as the oil, for example, and to consider the food from the point of view of that one constituent alone. Further, the relation which one constituent will bear to another has to be taken into account, and even more complicated does the question become when one has to consider the effect of one food when used in conjunction with another, possibly of a similar, possibly of a very dissimilar, kind. Still further, the proportions in which these different foods are used, the way in which they are supplied, the class and age of stock to which they are given, introduce factors which have a close bearing upon the economical utilization of the foods and of their constituents, and hence upon their actual value.

A further difficulty is that there is no 'market price' for the different constituents of feedingstuffs—the oil, the albuminoids, the starch, &c. —as is the case with nitrogen, phosphoric acid, &c., in manurial materials. The price of feedingstuffs is entirely regulated by a quite different set of conditions to those which prevail in the 'fertilizer market'. To a great extent the purchased foods of the farm come from foreign countries, and the regulation of the prices depends much upon demand and supply for purposes other than those of the feeding of stock. Many purchased feeding materials, such as linseed cake, cotton cake, &c., are only in a secondary sense of importance, so far as the producer is concerned; for when oilseeds like linseed, cotton, rape, &c. are crushed, the main consideration to the crusher is the *oil*, while the cake is merely the residue or *refuse* product, and, within limits, the more the oil can be expressed, the better for the crusher and the worse for the feeder of stock.

There are yet other points which present great difficulties in the fixing of the value of feeding materials according to their valuable constituents. Very little, to tell the truth, is known about the relative feeding values of any one constituent, be it oil, or albuminoid, or starch, as presented in the different forms of feeding materials. But it is clearly recognized that though an analysis may show two materials to have the same percentage of the chemical constituent known as 'fat' or 'oil', this has a very different value when presented in the one food than in the other. A high-quality linseed cake may contain 13 per cent of oil, and a delivery of rice meal may also contain 13 per cent of oil; but every practical feeder will know, and every agricultural chemist will acknowledge, that the oils in these two materials have very different feeding values, the linseed cake being highly esteemed because of its richness in oil, while the oil in the rice meal is reckoned as of but little account. Clearly, oils have very different feeding values, as they have also very different commercial values. The same holds good to a considerable extent also with the albuminoids, more especially when, as is often done, these are calculated from the amount of nitrogen present, and not according to the actual albuminoids present. No one would suggest, for instance, that the nitrogen in a material like peat moss possessed equal value to that in a truly albuminous material like decorticated cotton cake or bean meal. Similarly is it with the various carbohydrate bodies present in feeding materials. About these and their different feeding values comparatively little is known, but it is evident that much must turn upon their relative digestibility, and upon the power which different classes of stock possess of utilizing them. Cellulose, though it may be set out in the details of an analysis, is not of the same nature nor in the same physical condition in all feedingstuffs alike, and so is it with many other of the various bodies grouped together generally under the name of 'carbohydrates'. Even sugar and starch are not alike. Once more, the mechanical condition in which different foods are presented for the use of stock must exercise a considerable influence upon their profitable utilization, and, in addition, there are the differences of digestibility intrinsic to the nature of the foods themselves.

Such considerations as the foregoing make the valuation of feedingstuffs a matter of great complexity, and indeed, in the opinion of the writer, one of impossibility with our present very limited knowledge of the influence of foods in the feeding of stock for various purposes, and of the influence of one food upon another. So long, however, as only foods of closely similar composition and nature are compared with one another, it may be possible to approximately arrive at an estimate of their respective values based upon the percentages of oil, albuminoids, carbohydrates, &c., which they contain. This has been attempted in the plan known as that of ascertaining the 'food units' contained. This is based upon certain facts derived from feeding experiments, and according to which oil and albuminoids are assumed to have about equal value, and to have, each of them, a feeding value two-and-a-half times as great as that of the carbohydrates. The method of calculating the 'food units' is accordingly to multiply the oil and albuminoids by $2\frac{1}{2}$, and to add the results to the carbohydrates, the total thus obtained giving the 'food units' contained. Upon this basis, tables have been prepared giving the calculated 'food units' for the different feeding materials in common use.

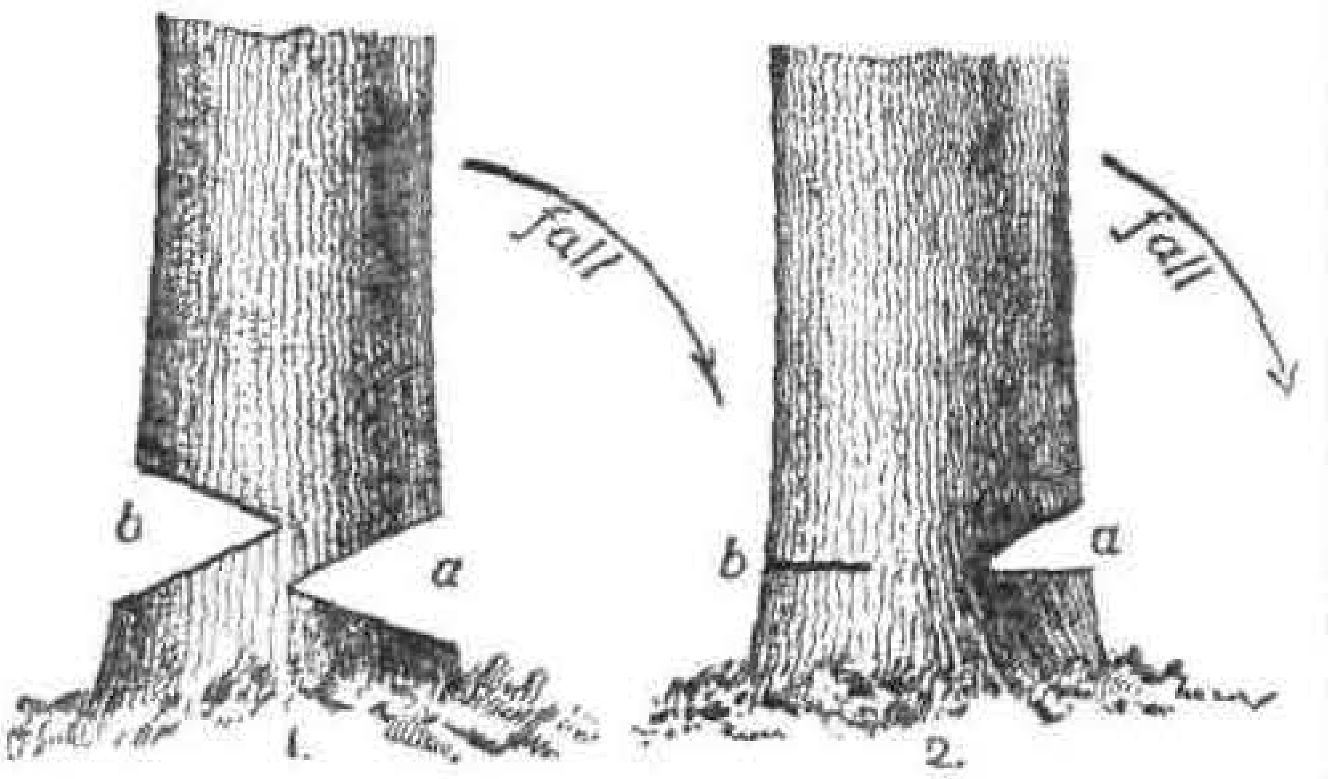
After what has been already said, it is needless to point out the many objections to which such a table lays itself open, or to indicate the many inconsistencies which it would exhibit. But it will suffice to say that so long as the comparison be made between foods of similar composition and nature, such a table may supply, within limits, a fair base of comparison, and give guidance as to the respective feeding values of the foods; but that with foods of different composition and differing materially in nature the comparison fails. Still later, attempts have been made to combine with the above the consideration of the relative digestibility of foods, as derived from the results of other feeding experiments, and to modify the 'food units' in the light of this, thus obtaining the total of 'food units digested'. This is in the right direction, though still open to the objection that it only holds good when foods of like nature and similar composition are compared. [J. A. V.]

Feering. See PLOUGHING.

Fell, the skin or hide of an animal; also (as a word of different etymology) a barren or stony hill.

Felling, a method of killing animals by means of the pole-axe, sledge-hammer, &c. See ANIMALS, SLAUGHTER OF.

Felling of Timber takes place with axe and saw, whereas the cutting of all small material in coppicing underwoods is done with handbills and billhooks. In felling large poles or trees with the axe alone, a wedge-shaped cleft is first laid in as low down as possible on the side to which the stem is to fall, and as far in as the centre of the trunk or beyond this. A second cleft is then made on the opposite side of the tree, with its apex pointing in the direction of that of the first cleft; and as the second cleft deepens the stem gradually inclines towards the opposite side. But as a rule all large trees and all poles over 9 in. in diameter at base should be felled with axe and saw, which is the usual and the best method. A cleft is first laid in for about one-fifth to one-fourth of the diameter of the tree on the side towards which the fall is desired, and then two men apply a big saw to the opposite side of the tree horizontally and on the same level as the cleft.



1. Felling with Axe Alone. *a*, First cut, in direction of fall, and as low down as possible. *b*, Second cut, on opposite side, and above *a*. 2. Felling with Axe and Saw. *a*, Cut with axe, in direction of fall, and as low down as possible. *b*, Cut with saw on opposite side (to be opened with wedges when saw is once well in)

When once the saw eats its way well into the stem, wedges have to be inserted to enable it to work freely; and these ultimately also assist in throwing the stem. To prevent their slipping, as they are specially apt to do in frosty weather, wooden wedges should have ashes or sand strewn on their sides, and metal wedges should be slightly toothed or grooved, or else a universal steel wedge should be used (which can be screwed up higher as the tree begins to incline). To assist in throwing the stem, leverage can also be applied in various ways. One of the best and most practical and powerful methods is the 'chain lever' (a German contrivance known as the *Waldteufel*, in regular use on the Morton Hall estate, Norwich, but not generally employed in Britain), consisting of a stout larch pole anchored to a firm base and with two short hooked chains attached to it, which can be alternately fixed, detached, and refixed higher up on another chain attached high up in the crown of the tree to be dragged over. This is a simple machine of great power and practical utility. Whether felling in woods should be done by the proprietor's own men or by men employed by a timber merchant who may buy timber standing, and whether it is preferable to fell by piecework, contract, or fixed daily pay, are questions that do not admit of any hard-and-fast answer. Other things being equal, a landowner's own men may be expected to be more careful of their master's interests; and this may count for much when timber is being felled and extracted. And certainly, when the work is carried out by the forester with local labour no dispute can possibly arise with the buyer about the timber not being felled and drawn out of the woods before the crops flush their young shoots in spring. Main points to be noted with regard to timber felling are that all the trees to be felled should be clearly marked; should be felled so as to give the largest possible outturn and to do the least damage to neighbouring trees, underwood, fences, &c.; should be at once cross-cut into the best size of logs and extracted to the nearest road, where also the smaller wood should be assorted according to class; and that felling operations should be suspended during high winds. The cost of felling, trimming, and logging timber varies locally, and with the size and quantity to be operated on; but on the average it may be put at from 1*s.* 6*d.* to 2*s.* 6*d.* per load of 50 cu. ft. (square-of-quarter-girth measurement) for conifers and softwoods, 2*s.* to 3*s.* for hardwoods generally, and 2*s.* 6*d.* to 3*s.* 6*d.* for oak. The coppicing of underwoods of about twelve to sixteen years' rotation usually varies from about 10*s.* to 15*s.* or more per acre, according to the density of the crop. [J. N.]

Felloe.—The term 'felloe' means either the wooden rim of a wheel or one of the treads which compose the rim.

Fell Ponies.—This hardy breed of native ponies ranges pretty much at large all throughout the Lake district of Cumberland and Westmorland, and even reaches as far as parts of Durham and Yorkshire, being named from the fells or hills of those districts.

They are larger and heavier than any of the more southern breeds, and can often be distinguished from any other breed of ponies by the tuft of hair on the fetlock joint. They are fast, active, and very hardy. It used to be no very uncommon thing for them to be covered up in the deep snows of their native mountains. They are thick-set, possibly with better-set-up tails than the other breeds of English ponies, but as a rule have not quite such good flat bones, nor such bright-looking heads and eyes.

It is not easy to find really pure specimens of the breed, but there must be many such ranging the hills almost wild.

For the most part they belong to farmers owning land which has allotments of hill ground attached to it, but they usually put them to selected sires, which it is to be feared are not always the most suited for getting stock able to withstand the rigours of the northern climate. It is a pity that a society could not be formed to keep up the breed in its original hardiness.

On the lower part of the Fells the breed, as is natural, becomes larger, and they are sometimes called Dales ponies; but whether of the larger type or the smaller hill type, they are a very valuable breed and well worthy of encouragement (see DALES PONIES).

It is very difficult to speak of their origin, but it is pretty certain that they are closely connected with the now extinct breed of Galloway ponies (which have become merged into the smaller type of Clydesdale) and with the breed of ponies found all along the west coast and islands of Scotland.

The possibilities of the breed of Fell ponies have been admirably illustrated in the distinction and fame which has been acquired by Mr. Christopher Wilson's breed of 'Sir George' ponies, descended originally from the Fell blood.

Good specimens of this breed may often be picked up as yearlings or two-year-olds at Brough Hill Fair on the last days of September and the first of October. [A. C.]

Felon, a malady in animals characterized by a swelling of the joints. See JOINTS, DISEASES OF.

Felsite, a convenient field term, of no exact meaning, for any compact igneous rock fairly rich in silica. Most 'felsites' are old lavas that have assumed a flinty character; others, like the 'quartz-felsites', are granular, and in reality are marked off from granite only by their fine-grained texture. The grey masses that form the north wall of Cader Idris are good examples of felsites. The compact varieties of such rocks yield but little soil, or one full of small white angular stones, and resist weathering more than any other igneous rock. In this they are even comparable with quartzites. The more granular types, including the Cornish 'elvans', give a sandy and usually poor soil, like that of granite. [G. A. J. C.]

Felspar or **Feldspar,** the name of a group of minerals which includes the most important rock-forming silicates in the world. The word is more correctly written 'feldspar'. The felspars are silicates of aluminium, with, in addition, potassium, sodium, or calcium. The principal species are as follows (Orthoclase crystallizes in the monoclinic system, but all the others are triclinic):—

Orthoclase (potash felspar), $KAlSi_3O_8$, silica 64·7, potash 16·9 per cent. Some soda is usually present.

Microcline is similar, but is triclinic. These two are the common felspars in granite.

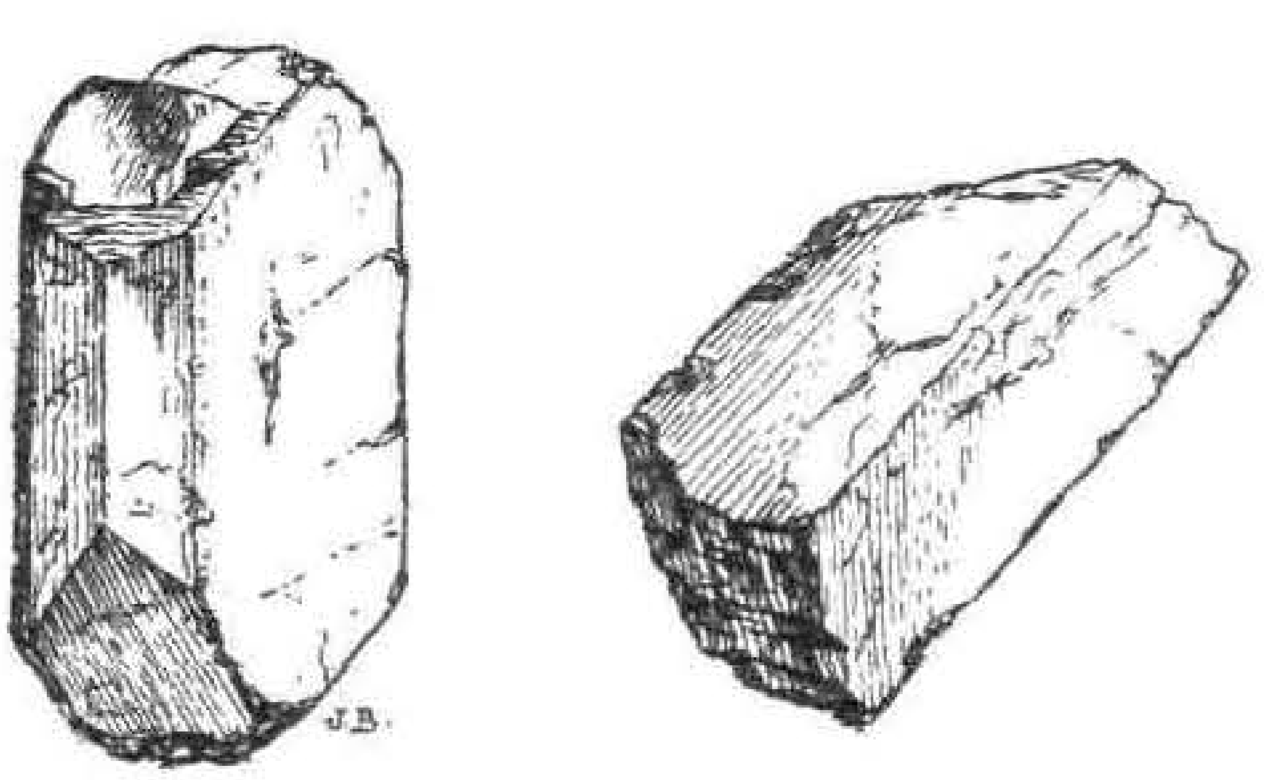
Albite (soda felspar) $NaAlSi_3O_8$, silica 68·7, soda 11·8 per cent.

Oligoclase (soda-lime felspar), between Albite and Labradorite, silica about 63, soda about 9, lime about 4 per cent. Common in diorite.

Labradorite (lime-soda felspar), between Oligoclase and Anorthite, silica about 53, soda about 4, lime about 13 per cent. Common in basalt and gabbro.

Anorthite (lime felspar), $CaAl_2Si_2O_8$, silica 43·2, lime 20·1 per cent.

The felspars thus form a continuous chemical series, the percentage of silica decreasing as lime



Crystal of Orthoclase Felspar showing Characteristic Form. On the right, a fragment showing the two cleavage surfaces at right angles to one another

increases. The hardness of all, when fresh, is such that they can barely be scratched by a file, and rarely by a pocket knife. They have two good cleavages, or sets of planes along which they break when struck. In Orthoclase, as the name implies, these are perpendicular to one another; in the other felspars, the angles between them become more oblique, down to Anorthite, where they are 85° 50′ and 94° 10′. All the triclinic felspars are thus sometimes styled *plagioclases*, or 'slantingly cleaved' felspars. All the felspars crystallize in prismatic forms, and those in lavas, such as basalt, are often small and rodlike, forming a delicate meshwork.

Another common character is their light colour, whitish, yellowish, and pinkish tints being frequent, though dark-grey occasionally occurs, as in some felspars rich in lime. Some felspars contain minute platy inclusions which produce an iridescent play of colours. The very fresh felspars of many lava-flows are clear and transparent.

The felspars of crystalline rocks are usually somewhat altered before they become exposed on the surface, and they undergo further changes as they are attacked by atmospheric waters. The most notable alteration is the removal of potash, soda, and lime in solution as carbonates, a certain amount of silica being also dissolved at the same time. A powdery hydrated aluminium sili-

cate remains, known as kaolin (see art. KAOLIN). This type of alteration takes place most readily in the alkali felspars, and kaolinization has often gone on deeply in a rock mass by the action of acids underground. Whether from surface decay or subterranean attacks, the rock which contains felspar as one of its main constituents crumbles and breaks up, while potash, soda, and lime become available in the resulting soil. The chemical analysis of a felspar will not furnish an accurate idea of the amount of these constituents that will be set free in a few generations, since the processes of decay work in many localities extremely slowly. The fresh condition of felspars in many of our oldest rocks, immediately below the thin soil resting on them, is often a matter of surprise. Those rich in lime decay more rapidly than the alkali felspars, and calcite is often developed at their expense. On the other hand, the lime sometimes becomes bound up in new combinations of a resisting nature, such as epidote and lime garnet, and the felspars become dull-grey or greenish, but are tougher and harder than before.

Thoroughly decomposed felspar produces a clayey soil, usually mixed with particles of other minerals from the parent rock. On exposed surfaces, the powdery kaolin is washed away almost as it is formed, and only a gritty residue of the less altered felspar and associated minerals remains as a coarse sand upon the surface. See art. GRANITE. [G. A. J. C.]

Felstone, a loosely used term, commonly met with on the older maps of the Geological Survey of Great Britain and Ireland, covering somewhat flinty or compact rocks of very different composition. Most of these occur in dykes, but their appearance and compact ground causes them to be distinguished from dolerite and basalt, the common 'whinstones'. In composition, however, some so-called 'felstones' contain more lime and less silica than basalts; others, on the other hand, resemble altered trachytes. Although many of the 'felstones' of our maps contain exceptional quantities of alkalis, notably soda, no conclusion can be drawn from the name as to the character of the soils locally derived from them. [G. A. J. C.]

Felted Ash Coccus. See APTEROCOCCUS.

Felted Beech Coccus. See CRYPTOCOCCUS FAGI.

Femeline Cattle.—This is a French breed of cattle established in the northern districts of Franche Comté, especially along the banks of the Saone and the Ognon. The distinctive characteristics of this breed are—a fine small head, moderately short and straight, fine small amber-coloured horns, and a quiet, gentle eye. The muzzle is large and the nostrils flesh-coloured, the neck fine and slender, the dewlap hanging, the breast broad and deep, the body is comparatively short, the ribs well sprung, and the outline straight. Altogether the appearance is distinctively feminine. Cows of this breed are noted for their quiet temperament and for their good milking properties. The bullocks are easily fattened, and yield about 55 per cent dead weight. The flesh has a very fine flavour and is much in demand.

Fen and Fenland. — Any low-lying marshy ground may be styled a fen, the characteristic vegetation being reeds and grass on a substratum of bog-moss or clay. The typical Fenland of eastern England is an alluvial infilling of the former estuary of the Wash. The 1300 sq. miles of fen from Ely northward 'have become dry ground within recent geological times, and the process is still going on' (Skertchly, The Fenland, p. 224). As the deltas of the Welland, the Nen, and the Norfolk Ouse spread into the old bay, the sea deposited fine marine mud or silt on their outer margins. Vegetation sprang up on the new land, formed alike by sea and river, and peat gathered in the swampy backwaters. *Hypnum fluitans* is the common peat-forming moss in the English fenland. Numerous lakes or 'meres' formerly existed; many of these have been drained artificially, while other reclamations have been carried out along the northern front, where new material is supplied by the sea from the south-east coast of Yorkshire. Stumps of oak, yew, and fir have been found beneath the fenland peat, which seems, as in other parts of our islands, to have spread during a damp cool period at the expense of forest vegetation. The alluvial fenland rests near Cambridge on Gault Clay, and northward on Kimmeridge and Oxford Clay; its gravels are derived from glacial deposits, rearranged by recent streams. The gravelly areas have long been inhabited, and progressive drainage operations in the broad 'Bedford Level' have greatly increased the area of arable land. The mud-laden rivers are confined between high artificial banks, and are thus maintained in a navigable condition. Lines of pollard willows mark the courses of the smaller streams. The roads are carried on broad embankments above the general level of the farms, which are reached by bridges across drainage-cuts full of peaty water. The peat is here and there cut out for fuel. The farmhouses often stand at some distance from the highways, protected by a few trees from the winds that sweep across the fenland. Though the rainfall is low, the air is often filled with heavy clouds, and a considerable range of temperature exists between midsummer and midwinter. [G. A. J. C.]

Fen Farming. See FARMING, SYSTEMS OF.

Fence-making Machinery.—Fence-making machinery is mainly used by large manufacturers who turn out immense quantities, especially of wire or iron fencing; but within the farmer's or estate's powers there are machines which can be profitably used. Messrs. Bacon & Curtis's 'Thrift' fence-making machine is well adapted to utilize underwood to make light continuous fencing, which is both durable and strong. Since in many districts underwood is of such little value as to scarcely repay the cost of cutting, it is convenient and profitable to make use of it in some way so that it may be employed where wood is scarcer. The machine is very simple, requiring no specially skilled labour to operate it. The fencing made by this machine consists of rods or stakes bound parallel to one another, with strands of wire which are

FENCE-MAKING MACHINE (by Messrs. Bacon & Curtis, Poole)

FERNERY IN GREENHOUSE

made to hitch round each stake. The fence can be made of any height, and the rods can be placed with any degree of closeness to each other as desired. The fencing is more durable when creosoted, but as it can be carried on post supports, and so not come into contact with the ground, this is not essential. Sheep netting of wire is largely used for fencing, as is barbed wire; but as continuous fencing the Page woven wire probably possesses unequalled durability, elasticity, and strength combined with lightness. The illustration of the loom (see Plate) shows the manner of making fences of this class. It is a loom working with warp and woof in steel wire, in which the loops shown are made. The continuous crossbars are knotted around every horizontal; the fence does not lose shape under any strains, and having greatest elasticity, immediately springs into position when any strain to which it is submitted is released; keeping its shape so well, few standards are required to keep it in position. [W. J. M.]

Fence Posts made of wood vary in size according as they are intended to be used as straining-posts or as standards. The straining-posts are usually 7 to $7\frac{1}{2}$ ft. long, and may be either of round timber or squared to about 6 in. (= nearly 2 cu. ft.). They may be fixed into the ground with soles, and are supported by stays about 5 ft. long and 6 × 4 in.; and in a straight line of fencing they need not be more than about 100 yd. apart, though required closer in curves or at angles. The standards are usually made of squared wood about 6 ft. long by 3 × 3 in., $3\frac{1}{2}$ × $3\frac{1}{2}$ in., or 4 × 3 in. square (= $\frac{3}{8}$ to $\frac{1}{2}$ cu. ft.), and are usually pointed for driving into soft ground, though the use of the mallet should be avoided on hard ground, as it strains the fibre of the wood and makes the top of the post soon take in water. For horses and cattle, standards are only needed every 12 to 18 ft.; but for sheep fences intermediate 'droppers' are required every 6 or 8 ft., to keep the wires apart at their proper distances. These droppers need only be thin laths (costing about $1\frac{1}{2}d.$ each), as they merely rest on the ground, and are not meant to support any of the strain on the wires. In their natural condition oak and larch make by far the most durable fence posts, but by the use of antiseptic preservatives the durability of Scots pine and even of softwoods like birch can be increased threefold and more. Thus, while uncreosoted fence posts of beech will decay in about 3 years, when creosoted they will remain sound for 15 to 20 years; and though posts of Scots pine only last about 6 or 7 years, by creosoting they are rendered serviceable for 15 to 20 years and above. Naphthaline is an equally good antiseptic, and at the Royal Agricultural Society's show in 1904 naphthalined stobs from the Duke of Buccleuch's Drumlanrig estate (Dumfries) were exhibited which were quite sound after having been in use for the previous $14\frac{1}{2}$ years (birch), 10 years (Scots pine and spruce), and 8 years (beech). Creosoting by immersion for 48 hours in an open boiler filled with creosote kept at a little above 212° F. costs about 6*d.* per cu. ft., and renders a cheap softwood like birch more durable than the best naturally seasoned and more expensive oak or larch. [J. N.]

Fences.—A fence may be, and frequently is, a boundary or division between two properties. Primarily, however, it is a defence against intrusion, or it forms a barrier or enclosure.

OBLIGATION TO FENCE.—1. *At Common Law.*—There is no obligation to fence land, though in England such an obligation may arise by prescription. Apart from prescription, every man must prevent his cattle from straying, failing which he is liable in damage to his neighbour. See under WINTER HERDING ACT.

2. *By Statute.*—In Scotland provision has been made for divisions between contiguous estates (see under MARCH FENCE), and special provision has also been made in both countries for the erection and maintenance of fences along the side of railways and public roads, and round quarries, &c.

(*a*) *Railway Fences.*—Railway companies are bound to make, and thereafter maintain, sufficient fences for separating the lands taken for the use of the railway from the adjoining lands, and protecting such lands from trespass, or the cattle of the owners from straying, together with all necessary gates and stiles. Such obligation, however, subsists only between the company on the one hand and the adjoining owners or occupiers on the other. That is to say, the company is only bound to fence against cattle lawfully using the adjoining ground. Where the highway adjoins the railway, the company must fence against cattle lawfully using the highway. The company is bound to maintain at all level crossings sufficient gates across the road, which must be constantly closed except where horses, cattle, or other traffic require to cross the railway, and proper persons must be employed to open and shut the gates.

(*b*) *Road Fences.*—The road authorities are not under any obligation to fence roads, except that, in England, where any alteration is made to an existing road, or a new road constructed through private ground or across any private or public footway, proper quickset hedges must be planted on both sides of such new-made roads, or in place of any fence which has been removed during the alteration. In Scotland the road authorities must erect sufficient parapet walls, fences, or adequate means of security along the sides of all bridges, embankments, or other dangerous parts of the road. (For FENCING OF ROADS AND ALLOTMENTS UNDER INCLOSURE ACTS, see under that heading.) Where cattle trespass on unfenced land immediately adjoining a highway the owner of the land must bear the loss, for the owner of the cattle is not responsible without proof of negligence. The only fences of which the road authorities take cognizance are hedges, which must be kept trimmed to the height of 6 ft. from the surface of the ground so as to prevent prejudice to the road by the shade thereof, and that the sun and wind may not be excluded. Trees, bushes, or shrubs in a garden, orchard, plantation, avenue, &c., are not to be cut unless they overhang the roadway so as to impede or annoy passengers. No one shall be compelled to trim any hedge except

between 30th September and 31st March. The use of barbed wire for fences in roads, streets, &c., is prevented by the Barbed Wire Act, 1893, which provided that the use of such wire in a fence adjoining a highway was a nuisance, and might be removed at the instance of the local authority. Moreover, the party erecting such a fence adjacent to a public road does so at his own risk, and is liable in damages caused thereby to passers-by.

(c) *Mines, Quarries, &c.*—Disused shafts, quarries, &c., must be sufficiently fenced. Where the ownership of the surface and the minerals has become separated, the owner of the minerals is bound to secure the surface owner against damage caused by the opening of shafts, &c. Moreover, anyone who opens a pit, quarry, &c., is bound so to guard it as to prevent injury to persons lawfully using a public road adjoining the pit, &c.

Upkeep and Repair of Fences.—In England there is not, apart from special agreement, any antecedent obligation on the landlord to put the fences into good repair. There is, however, apart from agreement, an implied obligation on the tenant to maintain the fences in the same state of repair in which he found them, for which purpose he is entitled to a reasonable supply of wood from the estate. In Scotland, apart from special agreement, the landlord is, as regards his tenant, bound to put the fences on a farm, at the tenant's entry, into a state of 'tenantable repair'. This has been defined to be such a state of repair as will render them capable of lasting well into the lease, and not necessitate a new tenant making extensive repairs on them from the date he enters the farm. This obligation only extends to the fences actually on the ground at the date of entry; there is no implied obligation on the landlord to fence unfenced ground. If the landlord fail to implement this obligation the tenant may, by action, compel him to do so, and find him liable in damages. If the fences have been put into tenantable repair the tenant is bound to uphold them in a like condition, and so to leave them at his removal. This obligation is, however, subject to the exceptions of (1) ordinary tear and wear, and (2) damage due to causes beyond the tenant's control. With regard to fences as fixtures, see under Agricultural Holdings Acts. The making of permanent fences is an improvement under these Acts for which the tenant may claim compensation. [D. B.]

Farm Fences

General Remarks.—In all civilized countries fences become necessary, and this is chiefly due to the transfer of common land to individual owners When common fields were customary, the necessity of setting a limit was not so pronounced, but now that individual occupation is the rule and not the exception some kind of division is required. It has been customary for many years to divide an entire area into fields, partly with a view to shelter, partly with a view to economy in labour. Farmers in years gone by paid marked attention to the laying off of fences, and we have evidence of this in the striking differences of soil in adjoining fields. We have frequently, when studying soil with a view to works of improvement, found that the mechanical condition of the soil changes when the fence is crossed. It is probable that the irregularity of fences, so common over the whole country, is chiefly due to this. No doubt in those days more attention was paid to the quality of corn than it is to-day; an even and regular sample doubtless turned the scale in prices, and the securing of this was helped by a close study of the soil. We are brought face to face constantly with the extraordinary acuteness of discernment manifested by the pioneers of agriculture. Before the days of special teaching, these men knew by observation what we gather now from study.

Of course, when land was not so valuable as it is to-day, more space could be occupied by wide hedges and hedgerows; the loss of area was not keenly felt. To-day close-cut hedges and rigid wire fences are more appropriate. We once made a calculation of the land occupied by fences upon a farm not modernized, and the area was so large as to be a serious loss, especially in respect of economic management; for rent, rates, and taxes were paid upon it equally with the cultivated land. No doubt there were advantages and compensations, but hardly such as would balance the loss of land. Small fields were common a few decades ago, and there was greater irregularity than there is to-day; but there remains sufficient evidence still to link the present with the past.

The change came with steam cultivation. Hedges were swept away, large areas were created in place of many small fields, and all with a view to a long straight furrow. Now many farmers regret the change, and would like to see the old fences back, for they lack the shelter for both live stock and crops. This desire on their part has evidently been present in the mind of the legislature, for the Settled Land Act of 1882 authorizes the expenditure of capital trust money in the 'inclosing, straightening of fences, and redivision of fields', and the Agricultural Holdings Act of 1906 places the removal and making of permanent fences in the first schedule. All this points to the fact that fences of some kind are essential to agricultural means and progress.

Arable Land.—Fields laid out purely for purposes of cultivation may be of large area; but if this be extravagant there may be great waste of corn when high winds search the open and exposed hill lands, and rush through bare valleys. It is wise to be moderate in area, and to recognize that a few straight, well-trimmed hedges or stone walls will effect much in the breaking of currents of wind which at times sweep over our arable lands.

The chief point to bear in mind in tillage land is that the fences should be straight, close and compact, and permanent.

Pasture Land.—In pasture land it may be different. Here shelter is the chief reason for the presence of hedges; and if they are wide and high, and even neglected, they serve their

purpose well. Small fields, irregular in form, with high hedges or wood rows, are invaluable where cattle are kept, for such arrangement not only affords shelter, but allows of rest and change of feed, so important to every class of live stock. These small fields enable a farmer to shorten his winter housing and feeding of cattle, for they find protection, where, upon exposed and open lands, it would be wanting.

Boundary Fences.—Another purpose for the erection and maintenance of fences is that of demarcation of boundary, *i.e.* setting an exact limit between two adjoining owners.

This is necessary to the twofold purpose of preventing the trespass of cattle and delineating the limit of ownership. Every man must keep his cattle upon his own land. There is no law to compel an owner to repair his fences, unless a prescriptive obligation can be proved. There is, however, an implied obligation upon the occupier in this respect. It is therefore clear that boundary fences are important, and should be efficient. Every gap or opening made, either by accident, in the felling of trees, or through mischief, renders the occupier liable for injury done by the trespass of his cattle.

The law respecting fences is important, but it is only necessary here to impress it upon the parties concerned, with a view to the planting and maintenance of effective fences.

Ownership of Fences.—Again, a boundary fence will, under certain conditions, carry upon its face the mark of ownership, and when this is the case such should be maintained. In the erection, too, of new fences this should be borne in mind. To illustrate this: If there be a hedge and single ditch between two properties, the hedge prima facie belongs to the owner of the field in which the ditch is not. It is well that

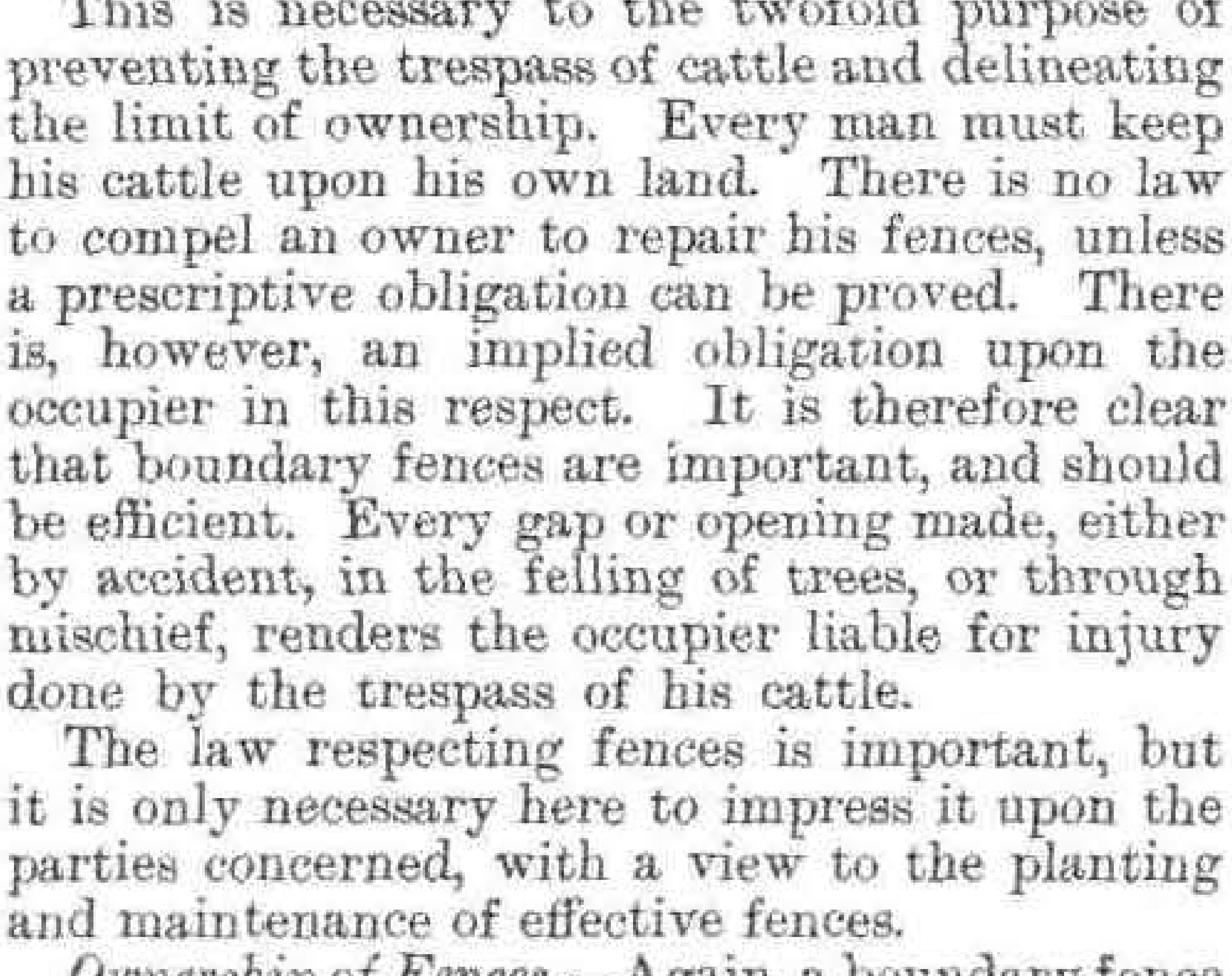


Fig. 1.—Example of Hedge and Simple Ditch as Boundary

this mark of ownership should be carefully maintained in any alteration which may be effected. If there be two ditches, one on each side of the hedge, the ownership must be proved by some acts of ownership. In this case, too, such acts should be maintained if existent.

The same applies in cases of dead fences, such as paling, post and rails, and so forth, the faces of which should lie toward the neighbour's land.

These points affect the subject of fences directly and indirectly—directly through their condition, thereby affecting economy in management; and indirectly through liability and responsibility in respect of maintenance.

Liability of Occupier.—An action for not repairing fences can only be maintained against

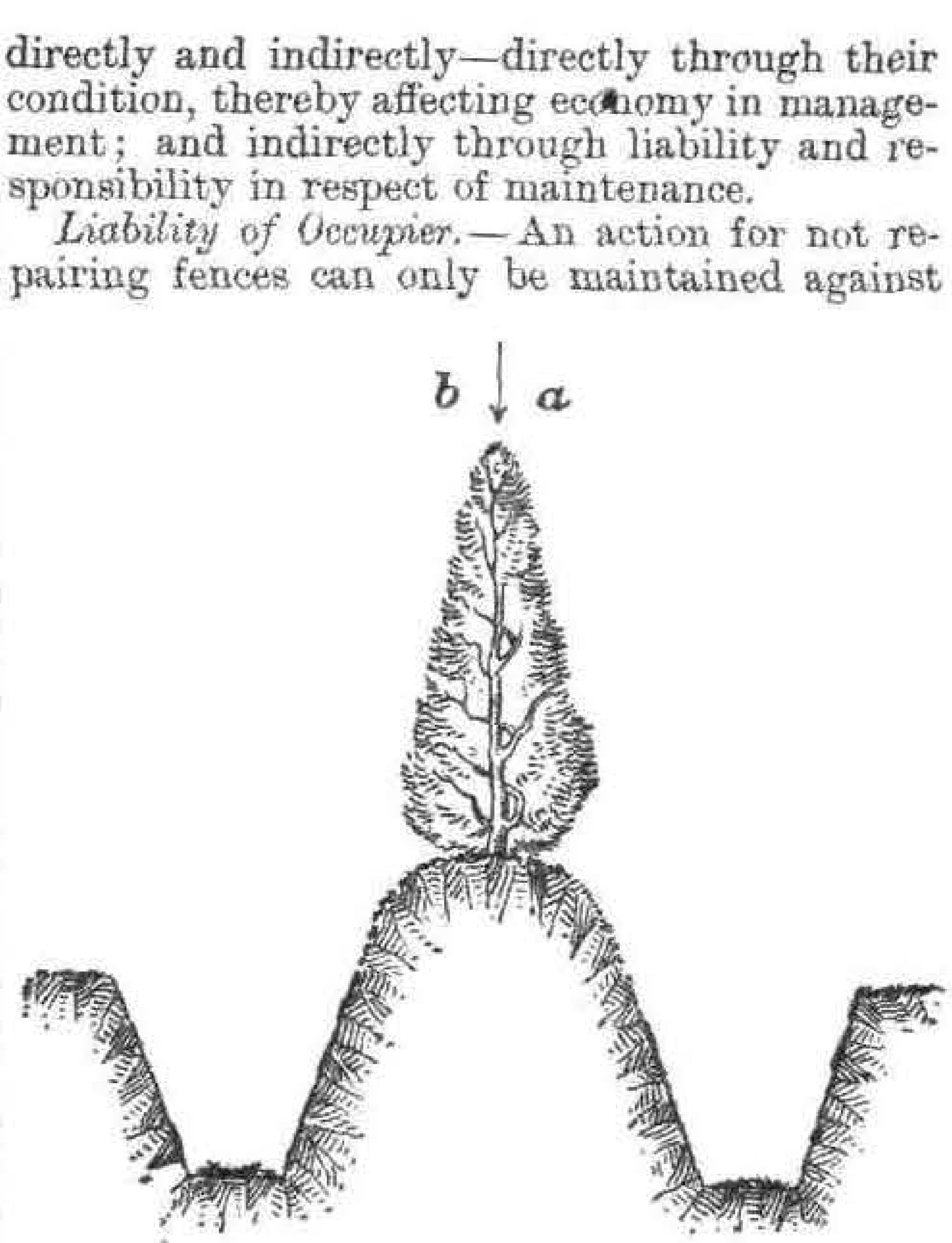


Fig. 2.—Example of Hedge and Double Ditch as Boundary

the occupier, unless the owner is bound to repair. Further, a tenant impliedly contracts to preserve ancient boundaries of the land occupied by him; and again, to maintain the fences of the property demised to him is an implied obligation—a covenant which 'runs with the land'.

It is only necessary to indicate this so as to emphasize the importance of keeping all fences, whether boundary or field fences, in reasonable repair.

Classification of Fences.—For the enclosure of fields, or for boundary, fences may be divided (1) into temporary and permanent, and (2) into those composed of materials with life and without. With regard to enclosure and boundary fences they may be taken now together, as the importance attaching to them respectively has been sufficiently explained. Temporary fences are composed of materials which will in due time decay; for example, post and rails and wattle or brushwood may be taken as the two extremes in respect of durability. Permanent fences are those composed of living trees, shrubs, or of stones. The term permanent must be used, of course, with some reserve, as shrubs may die, but in a practical sense they may be considered of sufficient life to merit the phrase.

Live Fences

The Chief Hedge Plants.—There can be no doubt that live fences, *i.e.* those formed of tree or shrub, take precedence of all others; it will be well, therefore, to give a list of those best fitted for the various local conditions of soil, site, and purpose. There are few trees and shrubs which may not be so trained as to form a fence, but the number of those fitted to form an impenetrable fence upon a limited space is

few. The essence of a fence lies in efficiency, with due regard to the area occupied.

The following list may be taken in order of merit:—

(1) Hawthorn, known as Quickthorn; (2) Hornbeam; (3) Beech; (4) Myrobalan or Cherry Plum; (5) Blackthorn; (6) Crab Apple.

The above are fitted for agricultural purposes, as they may with care be made to resist all classes of cattle. The following, though hedge plants, are better fitted for gardens and pleasure grounds:—

(7) Box; (8) Broom; (9) Gorse or Furze; (10) Holly; (11) Privet; (12) Yew.

Among trees and coppice plants which may be useful in forming wide rows for wind-breaks, but which will not bear constant and close cutting, are:—

(13) Hazel; (14) Ash; (15) Euonymus; (16) Wild Cherry; (17) Oak; (18) Willow.

Among the Coniferæ, too, many may be found useful, especially in exposed and elevated districts, where shelter is economically important. The Spruce Fir, the Mountain Pine, the Austrian Pine, the Hemlock Spruce, the compact and fastigiate Cupressineæ, and others may be taken as examples; but they cannot be taken as true hedge plants.

The Hawthorn.—It will be found a wise plan, and economical, to grow hedge plants upon the estate, for distribution among the farmers, and for the formation of new hedges. This does not necessarily imply the formation of a nursery (though such is very desirable), as any convenient piece of land can be fitted for the purpose temporarily. The Hawthorn, or Quick, may be chosen as the most universal and useful hedge plant; and as it is easily propagated, there should be a supply always ready to meet the requirements of the estate. The seed, known as haws, should be collected in October or November, or when ripe, spread upon the ground for a short time, and then mixed with sand and placed in a heap. The heap may be occasionally turned over during the first month, then covered over and allowed to remain until the following autumn, or, if preferred, the following spring. Some prefer sowing in the former, some in the latter; but this will be governed by local conditions of soil, moisture, and the like. The seeds when taken from the heap or pit may be found to have sprouted; if so, this will be in favour of early growth in the seedbed.

A seedbed should have been previously prepared, and the preparation, which is simple, may be as follows. If the soil be compact, double-dig a bed, 4 ft. wide, and of a length sufficient to meet the demand. Lightly dig in some well-rotted manure after thoroughly cleaning the ground, especially freeing it of all creeping grasses, such as couch and twitch, and from docks and other pernicious weeds. This preparation should be well in advance of sowing. If possible, it will be a good plan to take a crop of potatoes in the first season. The seed may be sown broadcast or in drills. If the latter, the drills should be 14 in. apart; if the former, the seed should be evenly distributed. Again, the seeds may be sifted from the sand and sown alone, or the sand and seed may be sown together as it comes from the pit. A bushel of seed may be expected to yield about 4000 plants. A covering of 1 in. of mould will be sufficient. It is a wise plan to sow the seed upon the prepared surface, and to throw mould carefully over it to the required depth.

As soon as the young plants are visible aboveground they should be weeded by hand and hoe, and the hoeing should be repeated at intervals throughout the year. By the following October the plants may be a foot or more in height, and the strongest should then be lifted and planted in lines; the weaker plants may be trodden in carefully and left for another year. When planted in lines the plants may be cut back to, say, 3 in., or this may be deferred. The lines should be 16 in. apart, and the plants 3 to 4 in. apart. Care should be taken in this replanting, as future success depends upon the abundance of root fibre when finally planted out. The best method is to cut a trench with one side vertical, and to place each plant, with the roots spread out, by hand, and to set them in mould, also by hand, before finally covering them by the spade. The whole line should then be firmly trodden in. The second year they may be planted when required. Those not required should be lifted, cut back, and again planted in line. All wounded root fibre should be cut off. When lifting, care should be taken to disturb the roots as little as possible, and this is best done by using two forks, or spades, together, one on each side. When nurserymen's prices range from 20*s.* to 30*s.* per 1000 plants for a size suitable for planting out, the saving by growth at home is manifest.

We have entered a little fully into the subject of preparation of seed and method of sowing, and the after-treatment, because, being the initial step in the making of a hedge, it is of manifest importance. It may be remarked that the stronger the plants, and the greater the abundance of their root fibre, the better will be the hedge. Old plants, provided they have been frequently transplanted, are the best for hedge plants.

Blackthorn and Crab Apple.—Although not in order in the list of merit, we consider it best to deal with the Blackthorn after that of Hawthorn, because the propagation is very similar. The seed of both is contained in a fleshy covering, which must be removed by rotting in a heap. Unlike the hawthorn, however, the seed of the blackthorn will be ready for sowing in the first spring after collection. The preparation of the seedbed and the after-treatment will be the same as that described. Strong taproots will doubtless manifest themselves, therefore the plants should not be allowed to remain too long in the seedbed, certainly not more than one year. When lifting them out of the bed, care should be taken not to disturb the roots. The best plan is, in both cases, to pull the plants out so as to disturb the surface as little as possible, as there may be still seeds left to germinate. This may be done without injury if the plants are pulled straight and without undue force. The following year, owing to irregularity of germination as stated, a second crop

as good as the first may be obtainable. The plants will be ready for planting out the year following—that is, two years after sowing. It will not be wise to leave them longer than this in the lines, because their roots are strong and vigorous, and they may lack in fibre. There can be no hedge so absolutely impenetrable as a well-grown blackthorn or crab, but more space will be required, and such hedge will lack the neatness of the hawthorn. They are inferior, but useful on poor land, where the hawthorn may not thrive. They are also very useful plants —perhaps the best—for the filling up of gaps in old hedges. One point should be borne in mind, that natural seedlings taken from woods and coverts are unfitted for hedge planting on account of the strong roots and taproots which belong to their nature. Blackthorn plants, one year transplanted, may be bought for 25*s*. to 30*s*. per 1000, and crabs for about the same.

The Beech.—Although a hedge of beech is not often seen as a farm fence, it possesses properties of great value, and it deserves a prominent place where shelter as well as defence is required.

It is a deciduous plant, but it retains its withered leaves throughout the winter, and often until the new leaves appear, and so affords a complete shelter. It may be trained to any reasonable height, to 15 ft. and more, and yet not take up more room than 3 ft. at the base. It is a tough plant, and capable of resisting great pressure, and when properly treated it will resist the heaviest cattle. It will grow best upon calcareous soils, but it will thrive well upon all land which is neither wet nor adhesive. The methods of planting will be described later; but it may be well to suggest that the arrangement should be of a trellis-work character, which will, as age advances, make a fence equal in strength to a stone wall.

The propagation of the plants is simple. The seeds ripen in the latter part of October or early in November. They may be collected after their fall from the tree; but care should be taken to reject those which are imperfect. After collection they should be kept in a dry place until the early spring, when they may be sown in beds prepared as already described. It will hasten germination if the seed is soaked in water for a few hours before sowing. The seed may be sown broadcast or in drills, the latter being preferable. When sown they may be flattened down with the back of a spade, and mould be thrown over them to the depth of an inch or two.

In the following spring they may be lifted and planted in lines, and in the following year they may be from 1½ to 2 ft. in height, and will then be ready for final planting out. When planting in lines it will be well to cut off the tops to aid in the formation of fibrous roots. If a strong hedge be needed in a limited space of time, it may be well to plant them in lines the second year. In this case the plants at three years of age may be from 3 to 4 ft. in height. They should not be cut back when planted out, except to the extent of shortening the leaders. Some prefer trimming the hedge of beech in the summer, as such treatment tends to thicken the growth. Soon after the cutting, numerous buds and sprays will develop, and bleeding is thus prevented. The sharp-pointed buds render this plant, when closely trimmed, almost as formidable as a quickthorn.

The efficacy of this plant for a fence against cattle will be enhanced if a ditch be made on the pasture side.

The Hornbeam.—The hornbeam is similar in many respects to the beech; in some it is superior, in others inferior. It is more restricted in respect of soil, but on clays and clay loams it will thrive better than beech. It will bear close cutting and great exposure, and it is therefore well fitted for high-lying and exposed farms. The retention of the withered leaves will, under the most exposed conditions, make it a very valuable shelter for both cattle and sheep. We have seen splendid hedges of this plant, intermixed with quick, growing in the Lothians of Scotland, the result both of care and skill. The treatment in the nursery is similar to that of the beech, except that the seeds should be placed in a heap with sand for a year before sowing, and then covered after sowing; 1 in. to 1½ in. of soil will be sufficient.

Beech and hornbeam, 1½ to 2 ft. in height, may be purchased for 30*s*. per 1000 plants. Care should be taken to select strong and well-rooted plants, and should there be weak plants among them, they should be planted in the nursery for a year.

Myrobalan Plum.—This is an excellent hedge plant, and under some conditions of soil it may be found superior to hawthorn. We have seen strong hedges formed of it upon poor sandy soil where neither thorn nor beech would thrive. It is a strong and vigorous plant and thrives well, and arrives at a sufficient maturity in a short time after planting to perform its functions. It will be found best to purchase the plants from a nurseryman, either as seedlings or as plants sufficient in size to plant out; and the latter can be purchased for 30*s*. per 1000 plants. If the former be preferred for passing through the nursery, the price will be about 15*s*. per 1000. A hedge of this plant, though tough and capable of resisting live stock, will not be so neat as hawthorn. It will take more room, and if neglected will grow wild, and be straggling in character.

This completes the list of hedge plants of the first class; and as those named therein are best adapted to agricultural purposes, it seems unnecessary to describe the others comprised in the second and third classes in similar detail.

Gorse, or Furze.—The only exception, perhaps, is gorse, or furze, which upon moorlands grows freely. The seeds of this plant may be sown at the base of turf walls, and on the banks formed of soil thrown out from the ditches. When young it serves both as a hedge and a shelter, but when old it becomes ragged and imperfect. Being very inflammable it is exposed to danger when the period of burning the forests sets in. Gorse hedges are usually found in poor forest districts, and when these areas are (officially) burnt, or burnt by passers-by, these hedges are in danger.

Formation and Management of Hedges

First Principles.—The foregoing remarks upon the propagation of hedge plants and the advisability of home production may be followed by a few suggestions, which may be termed 'first principles', applicable to all live hedges:—(1) In every case the bed of the proposed hedge should be trenched, or double-dug, and the soil rendered as uniform as possible. (2) A dressing of well-rotted foldyard manure will greatly assist in the early development. (3) Upon land which is wet, or which is likely to become wet in certain seasons, there should be at least one ditch. (4) When planted there should be a temporary protection fence; and, if rabbits abound, this should be in the form of wire netting, for rabbits will destroy in a few days the labour of months. (5) When planted there should be a systematic oversight for some years—weeding, forking, earthing up, and trimming once in every year. (6) Although there is an implied obligation upon the part of the tenant to repair and maintain fences, there should be an express covenant in respect of it.

Management of Young Hedges.—Newly planted hedges, if care has been exercised, should grow rapidly; but training will be needed to ensure success. This will be evident if we consider that plants suitable for hedges have a natural tendency to develop into small trees.

This proves that cutting and training are required to adapt it to its new purpose. The chief objects, then, of the planter are to encourage growth by liberal treatment, and to promote side shoots by shortening the leaders.

After planting (to be presently described) the hedge should be kept free from weeds, especially of grasses with creeping roots; the bed should be forked, and the ditch, if any, kept clear and free from obstructions. The plants may be cut off close to the ground, say to 3 in., so as to encourage a thick growth at the bottom. We think this the best method in the management of a hawthorn hedge; but some prefer to postpone the operation until the plants are established. It is an open question, and one to be governed by local conditions. There are few hedge plants which will not bear this close cutting. Where a young hedge, whether of thorn, beech, hornbeam, or other plant, refuses to throw out growth at the bottom, there is no alternative but to cut it close off; for an open bottom is a complete bar to future success.

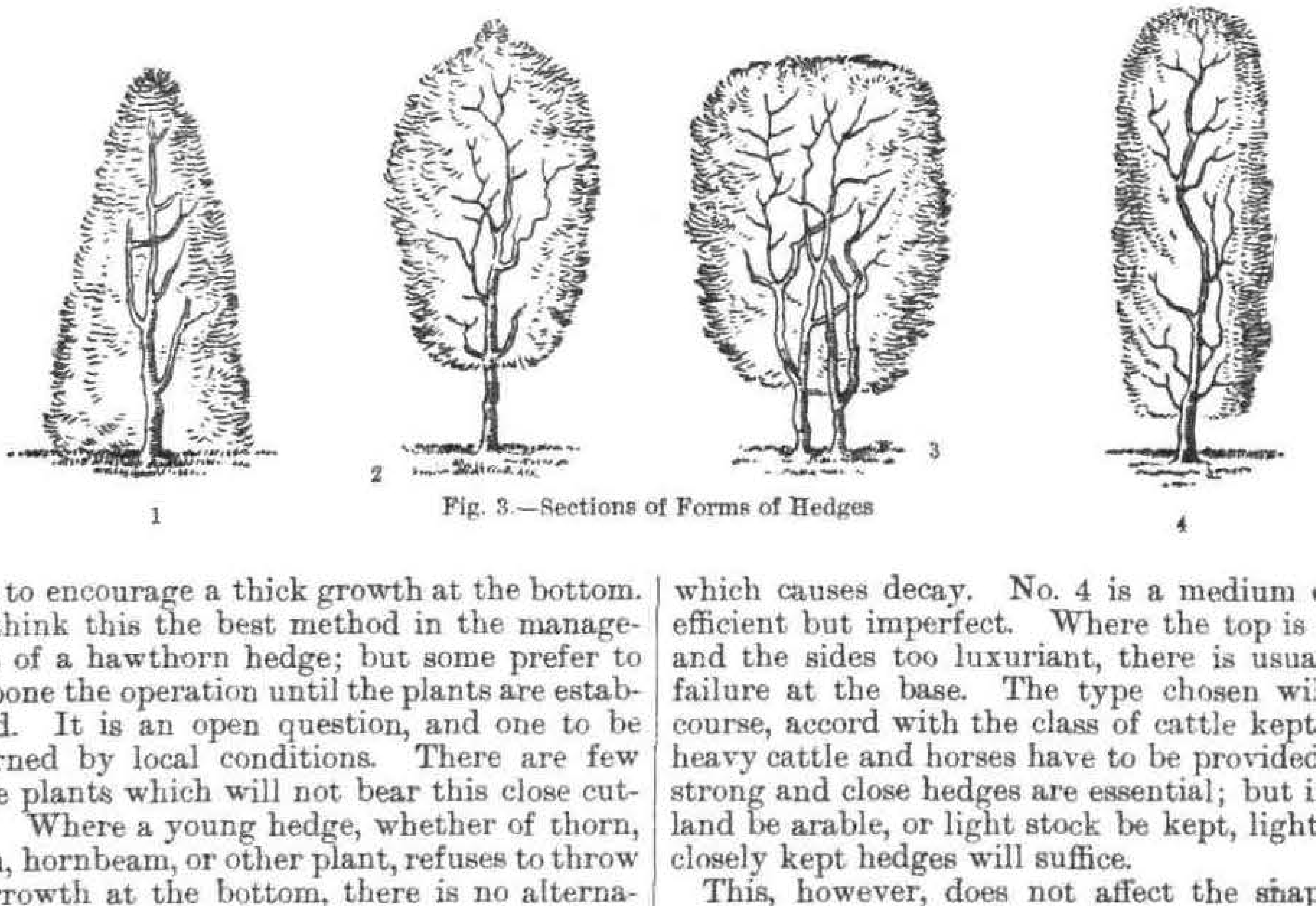


Fig. 3.—Sections of Forms of Hedges

Shape of Hedge.—As the hedge grows it will be necessary to determine the ultimate form or shape. It is easy to train, but difficult to reform. As to the form which a hedge should take, there are many opinions; but that which will secure a perfect base is the best. The examples in fig. 3 will serve to illustrate the advantages and disadvantages of the most common types.

No. 1 is the type most fitting for shelter and efficiency, as the tendency is to keep a close base instead of exhausting the growth at the top. The space occupied by it is limited, which is a feature of prime importance. No. 2 is effective as a hedge, but is bare at the base, and open for creeping sheep. No. 3 is unnecessarily wide, and therefore much land is wasted. A flat top, too, is subject to a growth of lichen and moss, which causes decay. No. 4 is a medium class, efficient but imperfect. Where the top is wide and the sides too luxuriant, there is usually a failure at the base. The type chosen will, of course, accord with the class of cattle kept. If heavy cattle and horses have to be provided for, strong and close hedges are essential; but if the land be arable, or light stock be kept, light and closely kept hedges will suffice.

This, however, does not affect the shape so much as it does the choice, in the planting of a double row at the time of planting.

Treatment of Old and Neglected Hedges.—New hedges, well planted, well trained, and kept in repair, will save a large amount of trouble and expense. It is, however, almost impossible to keep every hedge in repair upon a large farm or estate. All tenants, who are primarily responsible, are not alike in respect of their hedges and fences; neither are estates so careful in this respect as they might be. Due to this, some will become overgrown, some too thick and shapeless, some defective and inefficient, and some will die. This will necessitate drastic treatment. It will be the duty of the agent, when a tenant quits, to take notice of his obligation in this respect, and to insist upon the fulfilment of it.

An overgrown hedge can be brought back to its original form and usefulness in two ways—

by cutting down wholly or in part and allowing it to make a new growth, or by laying. The latter is the best, because a temporary fence for securing the former is avoided. If a hedge, say of thorn, be permitted to grow too high, the base will be bare, so that a simple cutting down to the correct height will not make an effective fence. The growth will be upright, and cattle will readily press through. Moreover something will have to be done in order to protect the hedge so as to allow side shoots to develop. The plan which serves the double purpose of reform and protection is that of laying. If the plants of the hedge are strong and uniformly placed, a selection may be made of those best fitted for uprights, so selected as to be about 2 ft. apart. These may be cut off to the height chosen. The remaining rods may be trimmed and laid over, first being partly cut through at the base, and interwoven among the standards. The longest and straightest should be woven in at the top so as to form the 'hether'.

In a hedge treated in this way there will be no dead wood, and after the first year the fence will be more effective than in its primary state. The cost of this operation will lie in labour only, and at a wage of 3*s.* a day the cost will range from 8*d.* to 1*s.* per rod. After this the hedge will be trimmed in the usual way, and will be absolutely impenetrable.

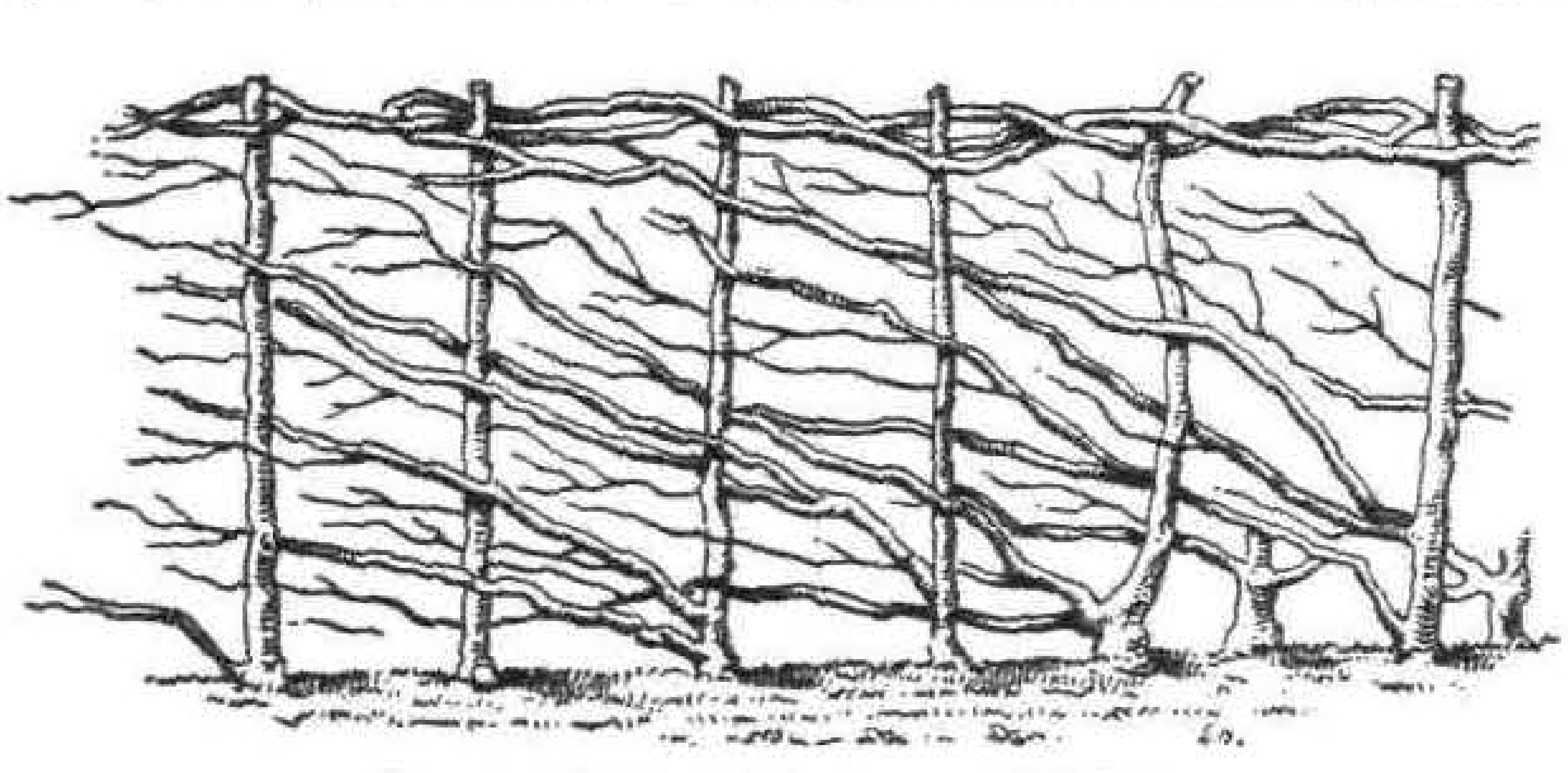


Fig. 4.—Method of Laying an Old Hedge

There are, however, in many neglected hedges a scarcity of plants, many wide gaps, and much bramble. When this is the case the first operation will be to cut away all brambles and unnecessary growths, to clean the ditches (if any), and to throw the sods taken from these upon the bank. The rods will be cleaned and made ready for laying. The process then will be similar to that described. Care should be taken as far as possible to use live wood, and this may be done by a good workman so completely as to render the use of dead wood unnecessary. Rods may be laid across gaps, and made so as to fill up in places where the natural growth is unsuitable. It will be well when laying a hedge to notch both the rods and uprights near the bottom so as to encourage the development of side shoots.

Filling up of Gaps.—When gaps occur in old fences which cannot be closed in by laying of rods, some plan must be adopted which will secure them from further enlargement. Perhaps the best method will be to introduce new plants. If the hedge be of thorn it may be best to plant up with blackthorn, crab apple, or plum, as quickthorn seldom thrives on the site of an old hedge. If, however, thorn be preferred, it will be necessary, first, to open the gap by the removal of every plant until strong and healthy plants are reached upon each side of it; and, secondly, to remove the soil from the bed and fill in with new. The new soil may be taken from the adjoining land. To this add some foldyard manure, and then select strong nursery plants and plant them carefully in a double row about 6 to 8 in. apart. If preferred, some plants of holly may be inserted in place of quicks.

Some protection will be necessary for a few years, and perhaps the cheapest method will be to drive in a few larch poles, and to nail upon them a rail, which may be of larch or fir sawn down the middle. This has the merit of simplicity and cheapness, and it will not crush or in any way smother the new plants.

Gaps have a tendency to enlarge, so that care should be taken to fill them in as speedily as possible. Much expense would be saved if notice were taken of gaps as they arise, for such arise almost entirely from trespass, and the boring of sheep and cattle, and if attended to early they may be closed by natural growth. Stopping by use of dead thorns or brushwood is most unwise, for the tendency is to make the gap larger through the destruction of the live wood at each end. Again, the use of wire, especially if barbed, is to be deprecated, for it is at all times dangerous, and being hidden, or practically invisible, is not always effective.

Wide and Overgrown Quickset Hedges.—Some hedges, though effective, have become wide and overgrown. These may be close cut down one side, and the side next the arable land or roadside should be cut first. The following year, if side growth has been vigorous, the opposite side may be similarly treated. In this way the hedge will be re-formed and yet be fully efficient. If both sides are cut in the same year, cattle are likely to force their way through, and so cause gaps. This process of 'breasting' is well known.

Treatment of Mixed Hedges.—Hedges consisting of hazel, ash, and other coppice plants will not bear annual trimming, and will therefore need periodic cutting and plashing. So far as possible, dead wood should be excluded; but dead stakes, if necessary, may be used. Some prefer these dead stakes, though they object to dead rods being woven in; for the stakes can be pulled out when they have performed their function.

A hedge of this description is seldom planted, though it often exists; and the probable origin is a remnant of a coppice area. If allowed to grow, though kept in subjection, it forms an excellent shelter for all classes of live stock. When cleaning the ditch, which usually accom-

panies such a fence, the soil should not be thrown upon the stools carelessly so as to bury them. The rods should be chosen from the best and longest hazel and ash, and these may be cut nearly through at the base, and woven in. All the rest of the growth should be cleared out and made up into faggots.

The cost of laying, cleaning out the ditch, and completing the work will range from 4*d.* to 5*d.* per rod.

Such fences as these, unless they are kept in repair, are apt to become defective, and therefore ineffective; and the gaps will be numerous and tend to enlarge. This is especially the case when trees are allowed to grow along the line of fence. There are instances in many parts of England where these old fences have become a source of vexation to the farmer, due to the cost of rendering them effective; and it would be wise where these conditions exist to grub up a portion each year, and, if necessary, replant with thorn or other suitable plant. The replacing of old and wide-spreading hedges by compact hedges of thorn or other plant would be an improvement of first magnitude. By this expenditure of capital the farmer would be relieved of a heavy annual burden, and at the same time be possessed of a feeling of security. He would also find the cultivable area much increased.

The Planting of a Quickset Hedge.—The points to bear in mind, and which apply to all live hedges, may be tabulated as follows: Plant during the months of October and November if possible; but if this be not possible, then in early spring or in open days between. In some seasons it may be possible to plant throughout the season, from October to April; but as a rule autumn planting will prove the most successful. After preparing the bed by trenching and manuring, select the strongest nursery plants with ample root fibre.

There are three methods of planting hedges. These are: (1) Planting along a raised bed, (2) placing the plants alongside of a bank thrown from a single ditch, and (3) planting on the level surface. It may be taken that the first is best if the land be wet, and if the soil be shallow. The second applies where the soil is shallow, exposure evident, and where water is likely to lie.

Wherever possible, however, the third may be selected as likely to produce the best results. This being the case it may be well to deal with it first. If the land be in tillage, and in good condition, the preparation will be simple. First lay off the line of fence—which should be as straight as circumstances will allow—and then measure off a bed 3 or 4 ft. in width. This should be trenched, or ploughed deep, in the autumn; and, if time be important, manure may be at once applied, at the rate of one load to 150 yd. of length. If time be not important, a crop of potatoes may be taken from it, and the planting of the hedge be deferred until the crop is harvested. This is worthy of full consideration, as the value of the potatoes may almost cover the whole cost of preparation; and the mechanical condition of the soil left after the crop has been gathered will be such as to encourage the rapid growth of the thorns when planted. If the land be in pasture the application of manure will not be so important, as the buried turf will serve equally well.

The cost of trench digging will vary a little according to the wages of the district and the nature of the soil; but it may be taken that simple trenching may be performed for 8*d.* to 1*s.* per sq. rod. For hedging the price is usually set at per lineal yard, and 1*d.* to $1\frac{1}{4}$*d.* should be sufficient.

There are two forms of trenching which it may be well to describe. First, the top turf is taken off, to the depth of 6 in., the first 2 ft. of the line of fence and wheeled back, or cast. The subsoil is then dug with the grafting tool, or fork, to the depth of 8 in.; upon this the next turves are thrown, being first chopped up; and so on until the line is complete.

The second method, though similar in some respects, is more complete, as the whole soil, subsoil and top soil, is completely turned over, and the bottom broken with the fork or pick-axe. This will cost more, but the results are likely to be more satisfactory. In the first the roots of the young plants will come early into contact with the crude subsoil; in the second the roots will be almost immediately nourished by the rotting turf. If the first be adopted, young plants should be chosen; if the second, the stronger the plants the better it will be. It is easy to conceive soils which will not require full trenching. Deep digging will suffice, and therefore much expense will be saved. If, then, the bed be ready for the reception of plants, the next process will be the planting.

The cost of thorns, if bought of a nurseryman, will be, for 1 to $1\frac{1}{2}$ ft., transplanted, 15*s.* to 20*s.* per 1000. If grown at home the price will be much less, say 50 per cent at least. Two men working together will plant 660 ft., or 10 chains, a day if the plants be in single line; if two rows are preferred the cost will be more, both for plants and planting.

The cost therefore will be somewhat as follows:—

	s.	d.
25 plants (about 8 in. apart) at 20*s.* per 1000 ...	0	6
Labour, of planting only ...	0	2
,, preparation of bed, say ...	0	7
Cost per lineal rod ...	1	3

The cost of a double row will be as follows:—

	s.	d.
50 plants (about 8 in. apart) at 20*s.* per 1000 ...	1	0
Labour, of planting only ...	0	3
,, preparation of bed, say ...	0	7
Cost per lineal rod ...	1	10

If the planting of potatoes has been adopted, the net value of the crop should be placed against the gross cost of the hedge.

The above has dealt only with hedges planted on the flat. We now proceed to deal with those planted under the first and second conditions.

Planting on a raised bed has advantages which

should not be lost sight of. A bank presupposes a ditch, and this upon wet land is desirable in more senses than one. It carries off the water and supplies a deep bed for the young plants. If one field be in pasture and one in cultivation the ditch should be on the pasture side, as it will to some extent serve as a protection to the newly planted hedge.

If the hedge be planted on a boundary line, the ditch should be cut to the extreme limit of the property and the soil thrown upon the land of the planter.

The first operation is to trench the ground 3 ft. wide along the line of the hedge; then lay off a line 1 ft. 9 in. from the centre of the line of hedge. This line will represent the inner side of the ditch. Cut this line to the depth of the turf with a sharp spade, slightly sloping it to the batter of the ditch. Then proceed to lay off the outside of the ditch, the width of which may be from 2½ ft. if an inside fence, and 3 ft. if on a boundary or roadside. Cut the turf on the opposite slope to the depth of the turf. The turf from the space of the ditch should then be carefully removed and laid so as to form the bank, leaving 3 in. between the inner side of the ditch and the toe of the bank. Those turfs should be laid with a bond, grass side downwards. The ditch should then be dug out, and if 2½ ft. wide, the depth may be 20 in. to 2 ft., and the breadth at bottom 1 ft. If it be 3 ft. wide, the depth should be at least 2 ft., and the breadth at bottom 1 ft.

The soil of the ditch will be thrown in as a backing to the turf wall. Next measure 1 ft. 6 in. on the inner side from the trenched ground,

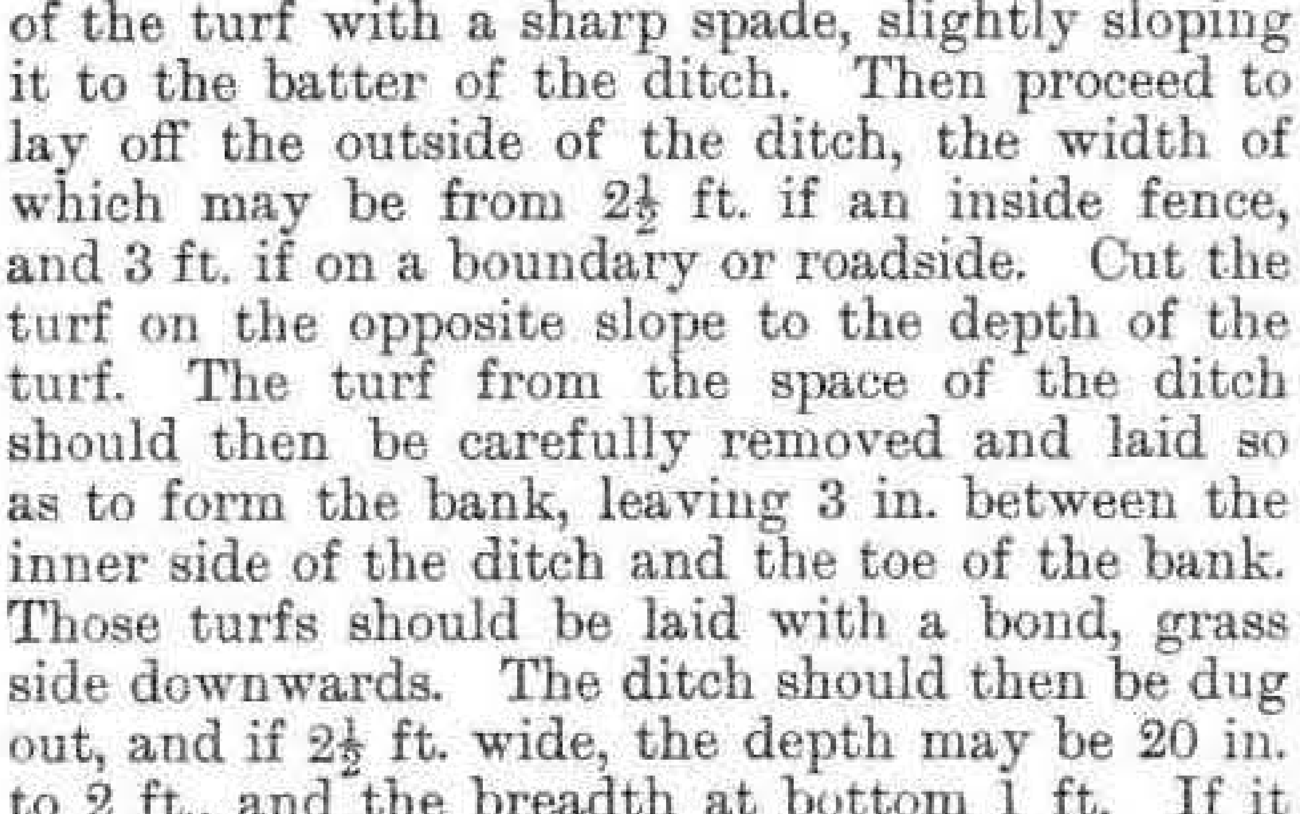


Fig. 5.—Section of Ditch and Bank with newly planted Hedge

take off the turf and cast it, grass down, upon the top of the bank. If the field be arable the same should be done, and the top soil cast upon the bank. The thorns may then be planted along the line set out. There will be a depth of soil which will ensure success.

If a boundary fence, two lines of quicks will be better than one; but if for the separation of arable fields only, one will be sufficient.

The thorn plants selected should be strong and well rooted, and not be planted deeper than they have been in the nursery. Too deep planting is often the leading cause of partial or entire failure. Opinions differ as to the cutting of plants; some begin by cutting the whole stem to 1 in. from the bottom, while others prefer to perform this operation after the plants have become established. Cutting of the plants at some early period is necessary, as it is the only way of securing side shoots, and hence a close bottom. Our opinion is, that if the plants be strong and well rooted, and 1½ to 2 ft. high, it will be best to cut them off 3 in. from the bottom at the time of planting; if young and less robust, the cutting may be postponed a year.

After planting, and for at least five years, the hedge should be forked and cleaned; every weed and all creeping grasses being carefully eradicated. Switching, too, should be carefully performed as soon as the leaf falls. This should be done with an upward stroke of a sharp knife.

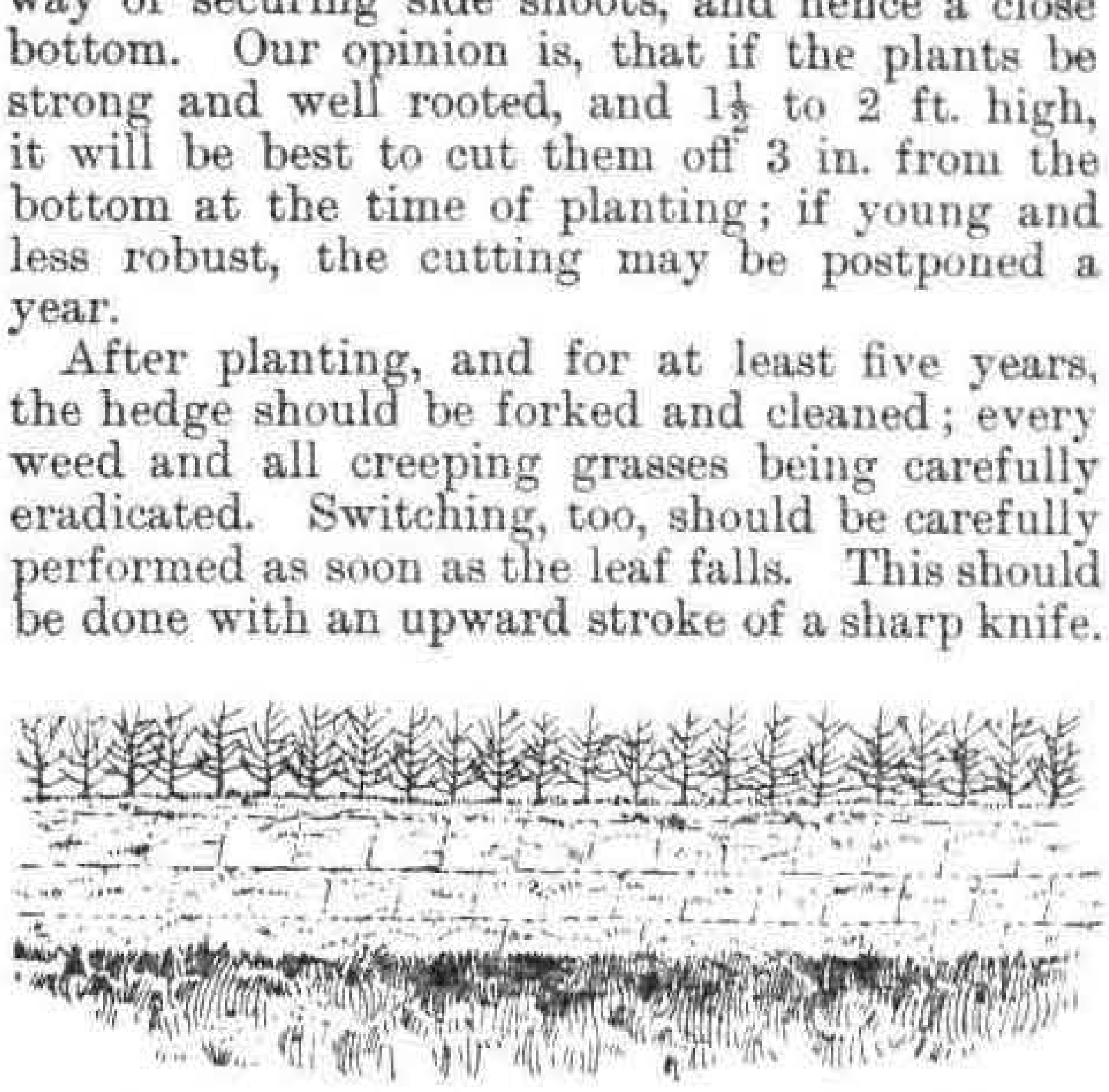


Fig. 6.—Elevation of Ditch and Turf Bank, with Hedge

At each switching the form of the hedge should be maintained according to that desired. Such switching may be performed for 1*d.* a rod.

There are several methods of forming a bank, but it is hardly necessary to describe each. The principles which apply are: (1) that the soil in which the hedge is to be planted should not consist of subsoil—in too many instances the turf is buried by the subsoil, whereas the reverse should be the case; (2) that the soil, before the ditch is made, should be trenched, as by this course there will be a double depth of soil as a bed for the young plants; while the subsoil broken below will serve well when the roots reach it.

When the preparations are complete a trench should be opened, vertical on one side, and on both sides if the plants are set double. The plants should be set in place by the hand against the vertical side, and kept in position by mould placed over the roots by the planter. A man will follow and fill in with a spade, and when complete he will tread in the whole firmly.

The process of planting is important, and too much care cannot be taken in spreading the roots, first cutting off all wounded fibre, and then burying to the correct depth.

There should be, so far as possible, uniformity in the soil and in the character of the plant, because by this alone a uniform hedge can be obtained.

Hedge on side of bank.—Another form is that of a hedge planted on the side of the bank. This method was much adopted in the Colonies in years gone by, and with excellent results. The process is as follows. The turf, if the field be pasture, is taken from the top soil of the ditch and laid along the inner side, leaving a margin of 3 or 4 in. at the toe of the bank. Soil is then thrown in at the back of the first line of sods; upon this the plants are laid at a right angle to the slope of the bank, and 6 to

8 in. apart. Another line of sods is then laid upon the plants and again backed with soil from the ditch. This is repeated until the work is complete. The height of the bank may be 18 in. above the hedge plants, more or less, according to the conditions of the turf.

For wet land, and for protection from sweeping winds, this method is a useful one.

Another form of fence, and one adapted to pasture lands upon which heavy cattle are

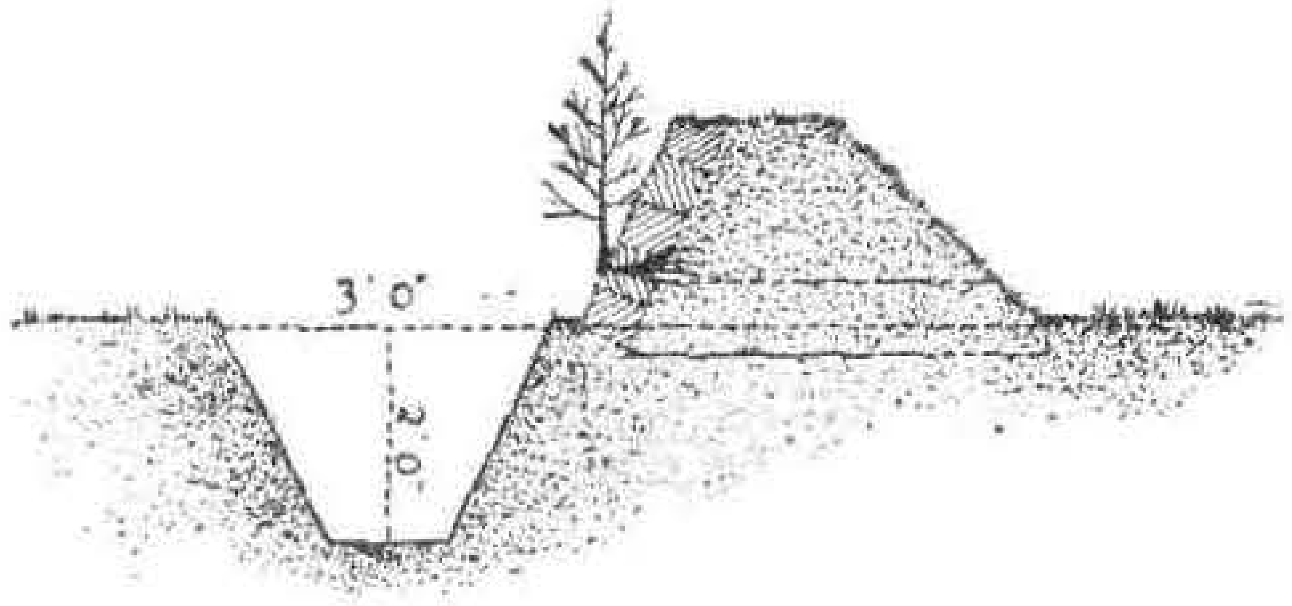


Fig. 7.—Section of Ditch and Bank, with Hedge on side of Bank

grazed, is that of a hedge and double ditch. If such a hedge be upon the boundary the ownership can only be determined by acts of ownership; but no such question can arise if on the inside of the property, and it may be taken that security or drainage were the leading causes for its erection. The chief drawbacks to such a fence are the space it occupies and the expense in formation.

The space, or width occupied, cannot be less than 8 ft., and this on a long line of fence is a matter of importance. Under such conditions a single line of plants should suffice, especially if strong plants are selected. A double line is supposed by many authorities to be necessary to secure efficiency; but experience has shown that a single line, if well planted and tended, will form a fence impenetrable even against the heaviest cattle. A double line, too, adds greatly to the initial expense. Strong plants set at 9 in. apart will do better than weak plants at 6 in., as they are likely to make stronger shoots at the base.

The cost of such a fence will be somewhat as follows, according to the rate of wages:—

	s.	d.
1. Trenching line of hedge, say 2 ft. 6 in. wide	0	1½
2. Digging ditch and forming bank, 2 ft. 6 in. wide, 1 ft. wide at bottom, and 2 ft. 6 in. deep, multiplied by 2 ...	0	11
3. Quickset plants at 20s. per 1000 ...	0	7
4. Planting	0	2
Cost per yard lineal	1	9½

The points of importance to bear in mind in the erection of such a fence are: (1) that the line of hedge, 2 ft. 6 in. in width, should be trenched; (2) that the turf from the top of each ditch should be set, grass downwards, along each side of the trenched bed, to the height of two or three sods, and the intermediate space filled in with the remaining turf and top soil; (3) that the subsoil of the ditches be cast aside, if not required to fill in; (4) that from 3 to 6 in. of unbroken soil be left on each side between the ditch and toe of the bank; and (5) that strong plants, in a single line, be planted along the line of prepared soil, at the rate of from 25 to 30 plants the rod. The protection of such a hedge will be dealt with under another section.

Beech Hedges.—Although thorn hedges have been taken as examples in the foregoing methods of planting, there are many other plants which will thrive equally well under like preparation and conditions. Among these is the beech, and there is no better plant if the soil and site are suitable. It has a peculiar strength, capable of resisting the heaviest cattle; and the pointed leaf-buds serve almost like the thorn to render it an impenetrable barrier. The strength may be still further enhanced by planting so as to obtain a trellis-work. It is a method adopted in France and elsewhere, but not so much as it might be in England. Strong plants should be chosen, say 3 ft. in height, and so set as to lean at an angle of 45 degrees. If one line only be chosen, then every second plant will lean in the opposite direction; but if two lines, one line may lean in one direction and one in the other. The points of contact may be secured by a tie of light osier willow. After years have passed, these points of contact will unite and so form a trellis, so complete as to be impenetrable. Under no conditions should the beech plants be cut close to the ground when planted; therefore pains should be taken to secure lateral

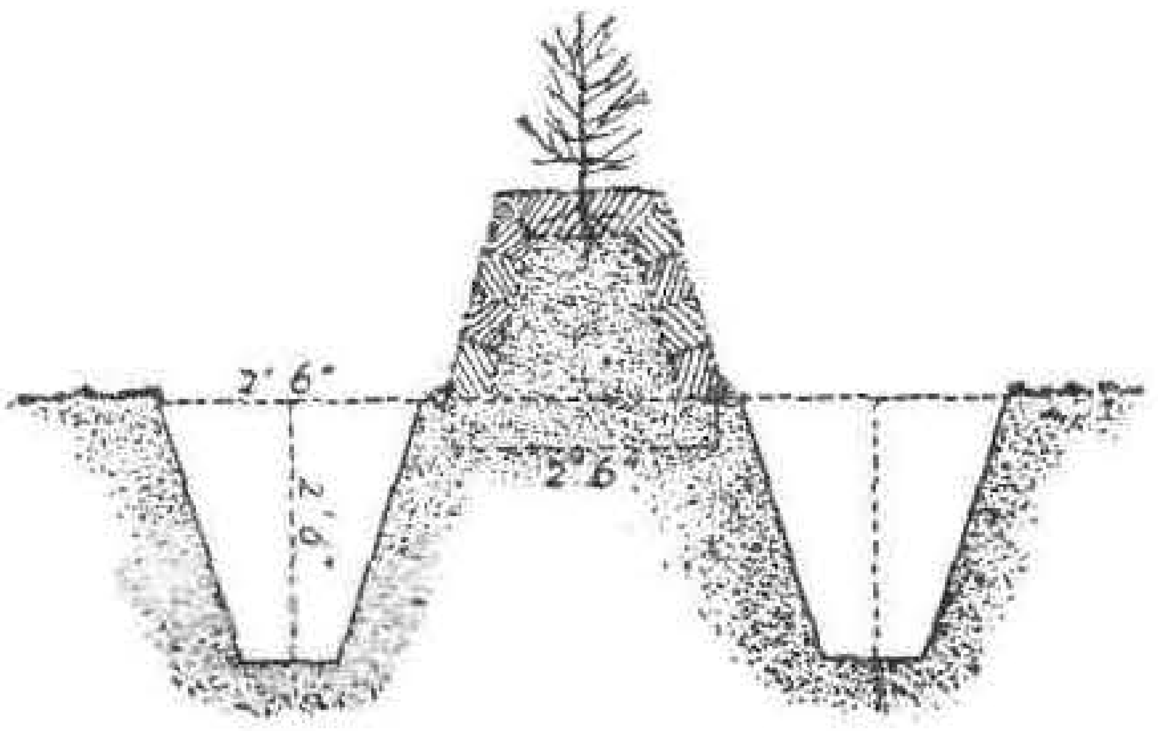


Fig. 8.—Section of Double Ditch and Bank, with Hedge on top of the Bank

growth from the start. Once the bottom becomes bare, no future attention will restore the loss. This may be secured by trimming, by protection from rabbits and hares, and by keeping the bed clean and free from creeping grasses and weeds. The beech when closely trimmed will carry the withered leaves until the new buds burst, so that the shelter afforded is both complete and valuable. The cost of such a hedge will be very similar to that of the thorn already quoted. The plants will cost more, as the quotation for 1½ to 2 ft. plants is 45s. per 1000; and plants 2 to 3 ft. will be much more. The number required, however, will be less, as, if the line be single and uncrossed, three plants will suffice to the yard.

Hornbeam Hedges.—A hornbeam hedge is very similar to one of beech, but it thrives on clay and clay loams better. Beech thrives best upon calcareous soils and lighter land. There are many good examples of hornbeam hedges; but perhaps some of the best are found in pleasure

grounds of old mansions. For agricultural purposes some of the most effective are those which are mixed with thorn. The two together make a stiff, pliant, and close fence, and bear well constant and close trimming. It, like the beech, carries the withered leaves into spring, so forming a shelter upon exposed lands. It will bear the knife better than any other plant. If the plants can be induced to grow without cutting back at time of planting, so much the better; but if they fail, cutting back 3 in. from the bottom may be resorted to. Shoots below the cut will be thrown out and so form a close bottom. Many failures, however, are due to carelessness at the time of planting and in after-management. The plant needs a well-manured bed, deep soil, and freedom from creeping grasses. Hornbeam plants may be purchased at 3 ft. in height for 40*s.* per 1000, and four plants to the yard will be sufficient. There is one point, which applies to both hornbeam and beech, which is of great importance to the farmer; it is that hedges of a great height may be grown in a minimum of horizontal space.

Other Live Hedges.—There are many plants which may be employed in the making of fences, but few, other than those named, are fitted for the making of fences capable of bearing the pressure of cattle and horses. Where high banks exist, and where there is exposure to cold winds, trees and shrubs, unfitted in themselves to form a barrier, may be selected; and among these may be named spruce fir, cypresses, holly, tamarisk, and others. These cannot be considered as true hedges, and therefore details as to planting and cost may be omitted. Before dismissing this branch of the subject, it may be well to state that many trees and shrubs will bear close cutting if it be commenced at an early stage of growth, but will resent it if cut back late in life.

Protection of Young Hedges.—In the planting of new hedges there must be a period in which protection from the attack of live stock is necessary, and also, where ground game abounds, an additional protection by wire netting. The only condition under which protection may be dispensed with is when the newly planted hedge divides two fields of land under cultivation. Here, if sheep be folded, there is no need for protection, unless it is to prevent damage by rabbits and hares.

The style of fence selected will depend (1) upon the cattle which are likely to graze in the fields; and (2) the material which the estate or district can supply. It will be necessary to retain this fence for a period at least of seven years, and in some cases for a longer period, so that attention should be paid to durability. There are various materials suitable—larch, ash, oak, willow, coppice plants, blackthorn, privet, thorns, and others, each suitable according to the conditions of supply. Wire, barb wire, and hoop iron will greatly aid where other material is lacking.

Among the most suitable may be named larch poles from the early thinnings of plantations. If such plantations exist upon an estate, there can be no better way of making use of the poles suitable. The largest may be cut into stakes, pointed, and driven in at distances of 4½ ft. For ordinary purposes, a fence 3½ ft. in height will suffice; if this be adopted, the stakes should be 5 ft. in length. The rails may be of poles, entire or sawn through according to size. The

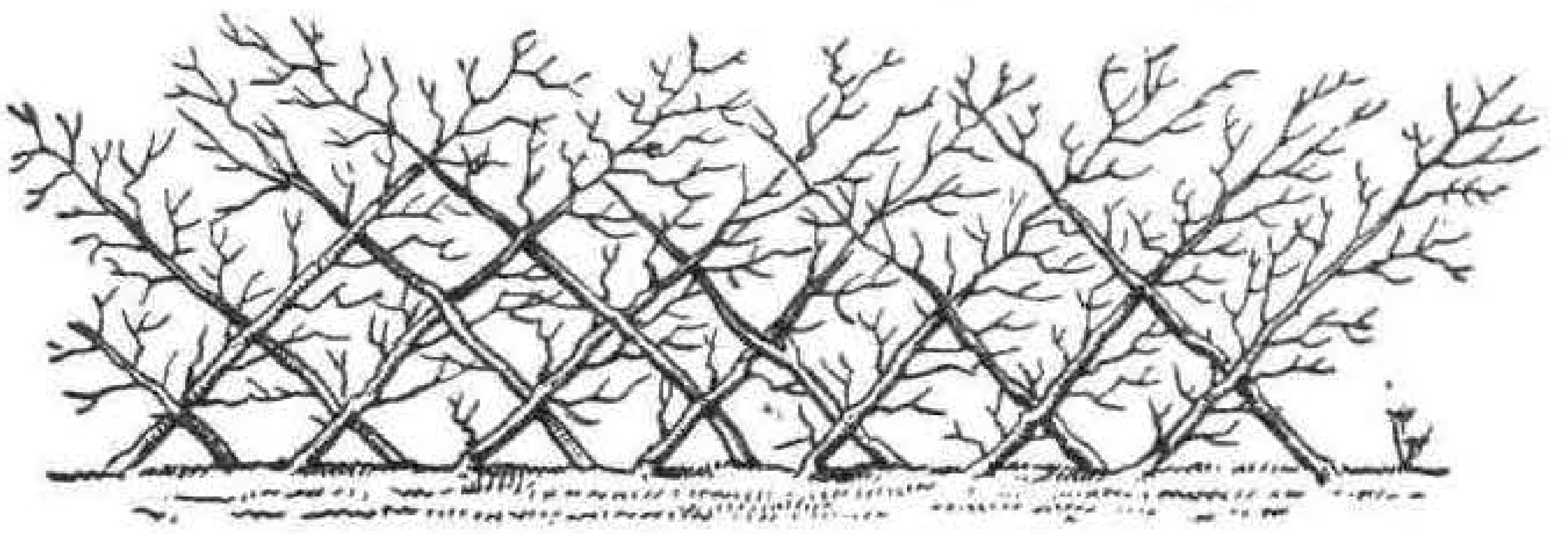


Fig. 9.—Example of Beech Hedge Trellised at Time of Planting

top rail may be nailed on to the top of the stakes or at the side as preferred. Three rails should be sufficient. This is a simple fence, but it will be found effective and durable. It will add a year or two to the life of the fence if the pointed ends of the stakes are dipped in tar and burnt, or creosoted, but where there is a sufficient supply of material within easy reach this may appear superfluous. Durability must be a matter of care and attention, for if imperfect it will fail to serve its purpose, and if neglected it will barely last for the time required. A new stake driven here and there, and a rail replaced

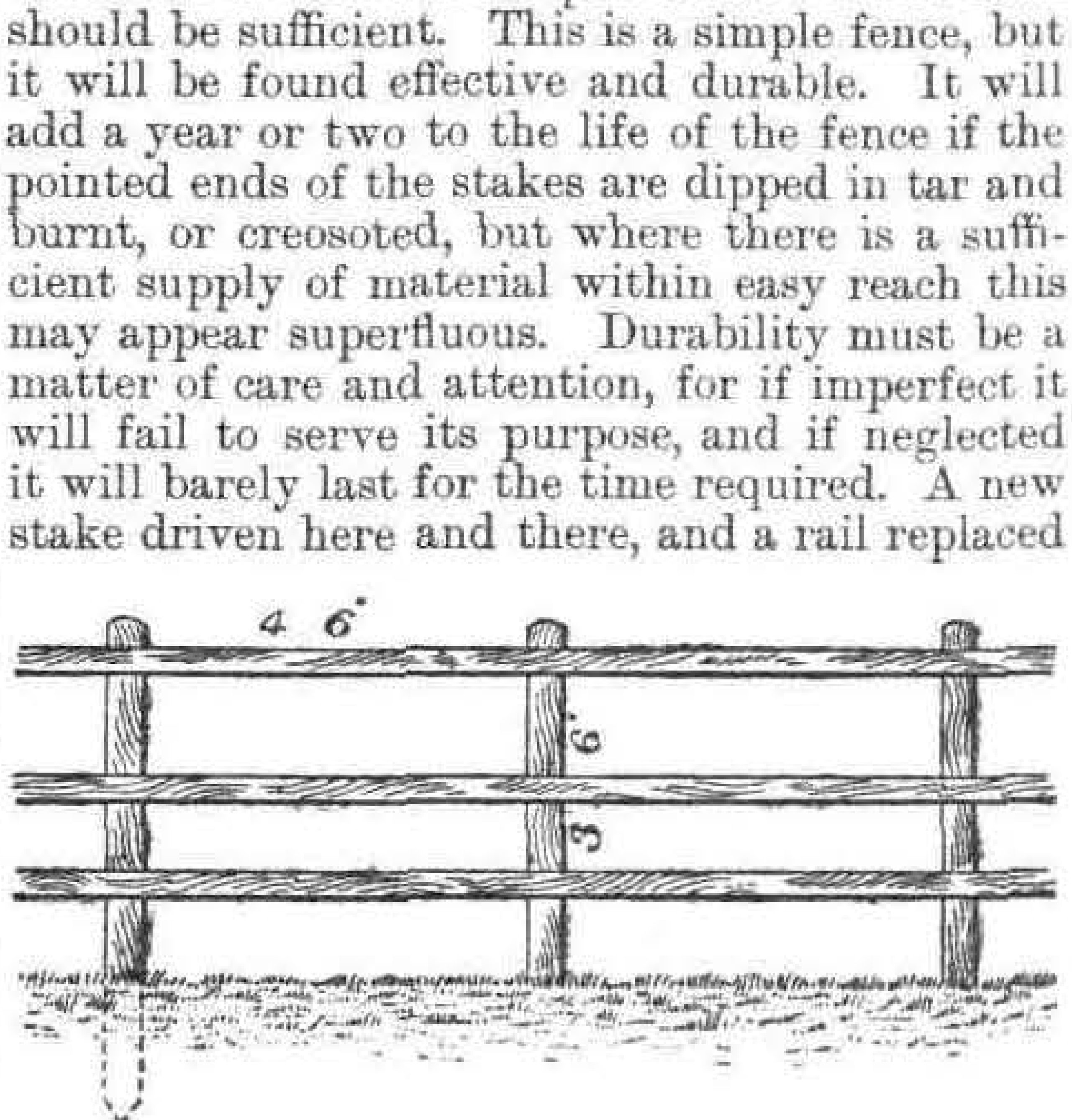


Fig. 10.—Example of Temporary Protective Fence of Larch or other Poles

where necessary, will doubtless carry it through.

The cost of such a fence may be quoted as follows:—

	s.	d.
Larch stakes, pointed and tarred, at 3*d.*	4	0
,, rails, 9 ft. (3 rails)	5	6
Labour and nails	3	8
Cost per chain	13	2
or, 7*d.* per yard lineal.		

The same fence may be erected of Scotch pine or spruce fir thinnings, but the life of such a fence will not be more than half of that of larch. It will be cheaper to erect, but dearer at the end of the seven years.

Another form, and best when fir poles are scarce, is that of wooden stakes and wire. Larch, or other stakes, from 4 ft. 6 in. to 5 ft. in length, pointed and tarred, and driven, with four wires

attached by staples. The staples should not be driven home, so that the wire may run when restraining becomes necessary. The top wire should be 3 ft. 6 in. from the ground, the second 2 ft. 6 in., the third 1 ft. 10 in., and the fourth 1 ft. If sheep be allowed to range over the fields, one more wire 6 in. from the ground may be advisable; but for cattle only, three should be suffi-

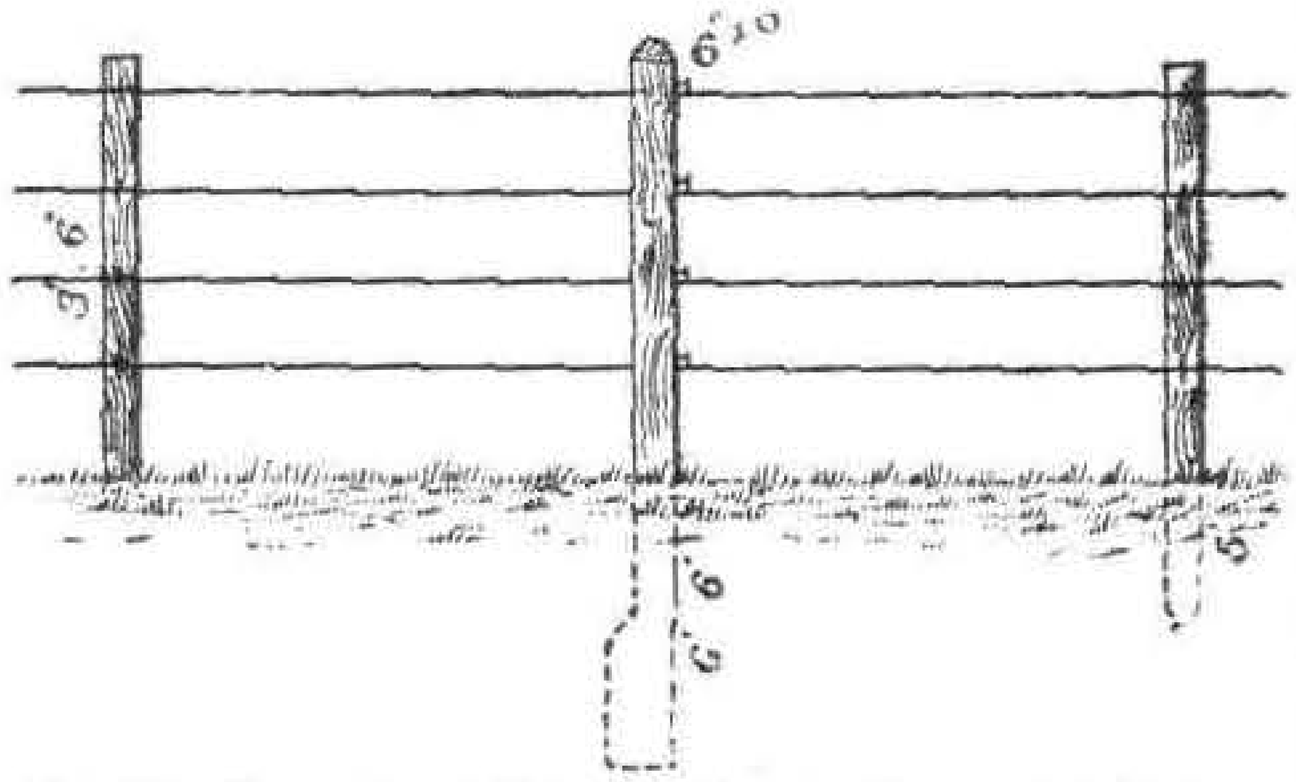


Fig. 11.—Example of Wire Fencing for Temporary Protection of newly planted Hedges

cient. To resist heavy cattle the stakes should be sawn, and not be less than 4 in. by 3 in. scantling. The strainers, which should be not more than 80 to 100 yd. apart, should be of oak, and have a scantling of 6 in. by 6 in., and be 6 ft. 6 in. in length. The cost of such a fence will range from 7*d.* to 8*d.* per yard.

The following is the cost in detail of a fence erected for the purposes described. Taking a length of 250 yd. Oak or larch strainers, stays, and stakes — stakes 5 ft. 6 in. in length, with a scantling of 4 in. by 3 in., and driven 5 ft. apart. Galvanized wire—top wire No. 4 gauge, four others No. 6, and bottom wire No. 7. Distance apart from ground, 6 in., 6 in., 6 in., 7 in., 8 in., and 9 in., equal in all to 3 ft. 6 in.

1 cwt. No. 4 = 250 yd. in length.
1 „ 6 = 350 „
1 „ 7 = 450 „

	£	s.	d.
1 cwt. No. 4, 3 „ 6, ¾ „ 7 } = 4¾ cwt. at 10*s.* 6*d.*	2	9	10
150 larch stakes, pointed, at 8*d.* ...	5	0	0
2 straining posts, 8 ft. by 10 in., at 7*s.* 6*d.* ...	0	15	0
2 stays at 1*s.* ...	0	2	0
1000 staples ...	0	2	6
Nails, say ...	0	0	3
Cost of material ...	8	9	7
Cartage ...	0	6	0
Labour at 1½*d.* per yd. ...	1	10	5
Total ...	10	6	0

or, 10*d. per yard lineal.*

The above represents a strong fence, capable of resisting cattle and horses, and will last, with occasional repair, for the *full period until the hedge can stand alone.*

Suppose that protection is only needed against rabbits and hares, or sheep, the following fence may be found suitable. It will certainly be effective. Height of fence, 3 ft. A top wire of gauge No. 7, wire netting 42 in., mesh 1¼ in., and gauge No. 18. Stakes 4 ft. 6 in. in length, scantling 3 in. by 3 in., 9 ft. apart:—

	£	s.	d.
2 light straining posts, 7 in. by 7 in., at 4*s.* 6*d.* ...	0	9	0
2 stays at 6*d.* ...	0	1	0
100 larch stakes, 4 ft. 6 in. long, at 3*d.*	1	5	0
¾ cwt. No. 7 galvanized wire ...	0	8	0
6 rolls galvanized netting at 12*s.* ...	3	12	0
12 lb. lacing wire ...	0	2	6
Staples ...	0	0	3
Cartage ...	0	6	0
Labour at 1*d.* per yd. ...	1	5	0
Digging trench to cover netting and filling in, ½*d.* per yard ...	0	12	6
Cost per 300 yd. ...	8	1	3

or, 6½*d.* per yard.

The above will prove a strong and *lasting* protective fence. It should be noted that 6 in. of the netting should be turned over towards the outside and buried in the trench provided, as this will prevent the rabbits from burrowing under.

Another form of fence, suitable where coppice is within reach, is that of wattle. This may be composed of hazel, ash, willow, thorn, blackthorn, and other plants. With occasional repair it may last from four to five years. It has the merit of affording shelter for the young hedge, and to *some extent it will protect from rabbits.* The cost, if the material has to be purchased, and including haulage, will be about 5*d.* to 6*d.*

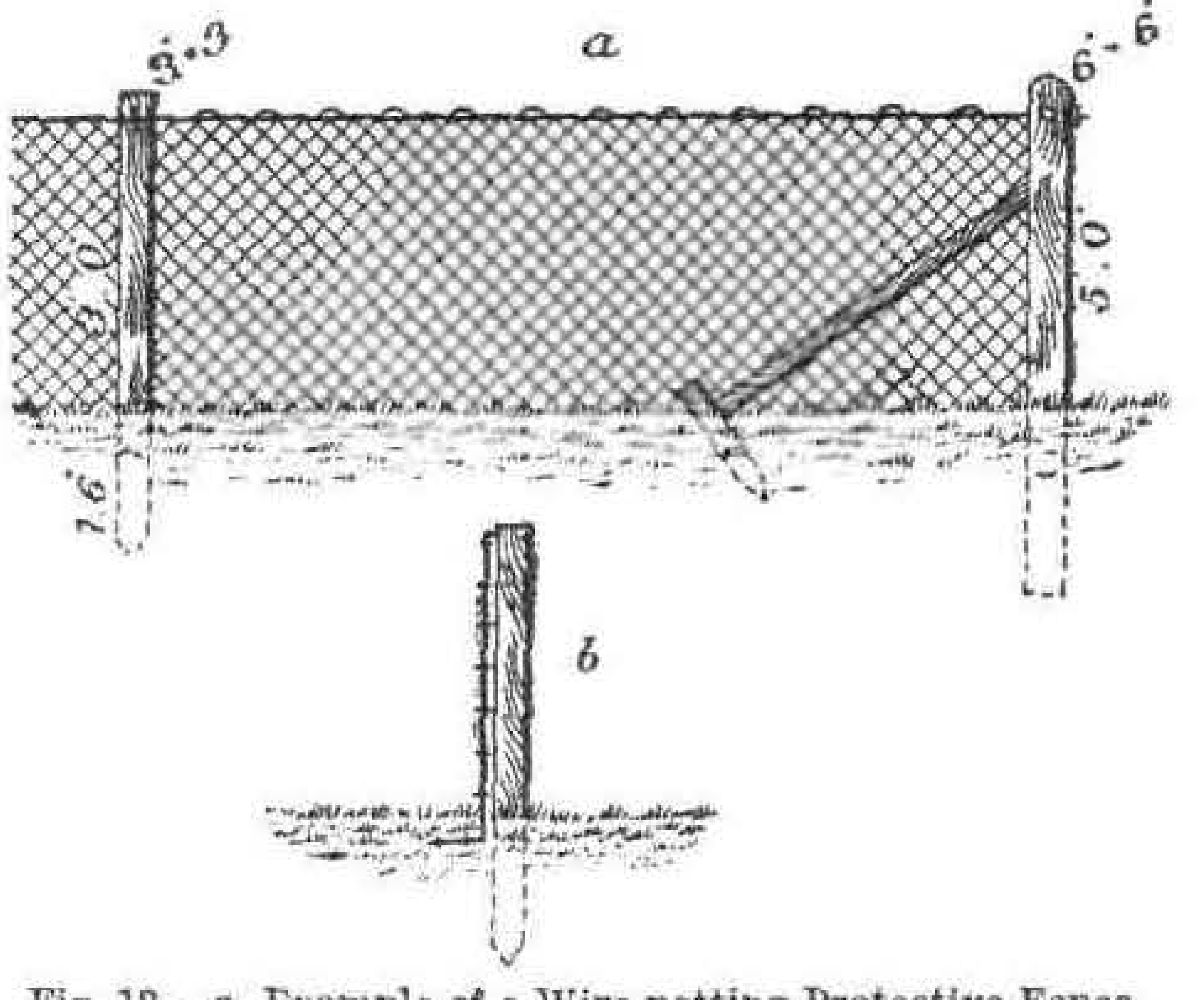


Fig. 12.—*a*, Example of a Wire-netting Protective Fence. *b*, Section, showing the Turning-over of the Netting.

per yard. It seems hardly necessary to describe the method of erecting this, as it is so well known to all concerned in husbandry; but briefly, it is as follows: Stakes are driven in about 1½ ft. apart, from 3 to 3½ ft. high. Then the brushwood is woven in front and behind the stakes to the full height. The hethers, or edders (that is, the binders) may be of ash, hazel, or privet, or, in fact, of any pliable rod. There are various ways of cheapening the process, *such as fixing thorns into the ground and binding them together at the top;* by driving stakes at wider intervals through which a binder can be woven; but cheapness in such a case means only an initial saving. In the long run a greater expense will be incurred. Upon sheep-farms where wattle hurdles are used for the folding of sheep, those which have served their purpose for the fold, but have still a life in

them, may be used for the purpose of temporary protection. It is, of course, conceivable that new hurdles may be selected as a protective fence, and, apart from cost and durability, there can be no better. The cost of such will be about 5*d.* per yard; but as the life of such a fence will not exceed three years, it will have to be repeated before the hedge is safe.

Another method, not entirely efficient, is that of stakes, and of one or two lines of barb wire attached to them. It has the merit of cheapness, but in other respects it is unsatisfactory. The cost of protective fencing, especially when it becomes necessary upon both sides, adds materially to the initial cost of hedge planting; but without it the whole money expended would in many instances be wasted. All animals, whether cattle, sheep, or horses, hares or rabbits, are fond of the shoots of young thorns, and will do great damage in a very short time. If a hedge be looked upon as a permanent improvement, money should not be spared to render the improvement effective and durable.

Summary.—Before passing on to dead fences, it may be well to briefly summarize the points which are essential to success of live hedges. (1) That plants be chosen of a kind suitable to the soil, site, and aspect; (2) that the kind chosen shall be such as will form an impenetrable barrier against such cattle as are customary in the district; (3) that the plants will thrive under constant cutting and trimming; (4) that the bed of the hedge be deeply dug and well manured, and that so far as possible the roots shall find their way early into the turf soil; (5) that the plants chosen be well rooted, the wood ripened, and the stem erect; (6) that after planting the bed be forked and weeded, and that all creeping grasses and other weeds be obliterated; (7) that constant attention be paid to the hedge for at least seven years after planting, and that the shape of it be maintained; (8) that pains be taken to secure and keep a well-furnished base; (9) that some efficient protective fence be erected and maintained until the hedge can stand alone.

Dead Fences

The term 'dead fence' applies to such as possess no life, that is, such as are permanent or temporary according to the material employed, but are incapable of recuperation. These fences have an advantage over those live hedges which have been described, in that they become effective from the time of erection. That erected to-day is effective to-morrow, and will remain so so long as it is kept in repair. The materials suitable are stone, earth, turf, timber, wood, iron, scrub, &c.

Stone Walls, or Dykes.—Stones suitable for the building of dry walls are found in many districts, such as the Black Slates and other rocks of Cumberland; the Oolites of Dorsetshire, Gloucestershire, Lincolnshire, Northamptonshire, Oxfordshire, Yorkshire, and other counties, and other rocks found in many formations. The rocks suitable may be classified as (1) those of a slaty nature, laminated, and within easy reach of the surface; and (2) those of boulder form. The first are best, as they lie flat; but the second are capable of forming excellent walls if built by men who are accustomed to the work. The essential economic point in the building of dry walls for field division is that the stones shall lie on or near the surface, and that the haulage of them shall be within a minimum cost. To purchase stones from a distance and to cart them to the site will render the fence more costly than if of wood or iron. It is due to those considerations that dry walls are confined to limited districts. A dry wall is somewhat dreary in aspect, but it harmonizes usually with the open and exposed sites upon which it is so often erected. It has the merit of affording shelter to both sheep and cattle, and also of assisting in the rendering of exposed land more amenable to culture. Further, it occupies a minimum of space, as no ditches are necessary, (1) because the land under such conditions is usually dry, and (2) because a narrow well-built wall is capable of resisting the pressure of the heaviest cattle. And again, it is lasting, the duration is unlimited, and after the first cost the annual expenditure in repair is trifling. Labourers in those districts are usually experts in both building and repair; but there are a few essential points which it may be useful and interesting to describe. Fences for the division of the fields are built dry, that is without mortar; but those which are built for the boundary of a public road, or for other important boundary, are, or may be, 'harled' with mortar or clay; and the coping of such should always be set in mortar. We propose to deal with the former only, as the principles of building will be the same in each case.

The walls should be as solid as they can be made, and 'through bonds' should be liberally placed. In the course of construction the courses should be brought to a level at frequent intervals, and care should be taken to maintain a vertical mould. The top should be coped with the best stones set upright and on edge, and with a reasonable overhanging so that rainwater may fall clear of the face of the wall. The coping should be wedged from time to time, so that the whole may be firm. If these points of structure are omitted or carelessly carried out, the result will be a loose formation, leading to early dilapidation. It may be taken that the top of a stone wall should never be less than 1 ft. in width, and this irrespective of the width of the coping.

If, then, the height be taken at 4 ft. 6 in., the width of the bottom will depend upon the mould of the wall. The taper, or slope, may be one-sixth of the height, therefore the width of the bottom will be—if $4\frac{1}{2}$ ft. be taken as the height—2 ft. 6 in. This width should be measured, and laid off along the line of fence. It will add to the strength if the sod be first removed. Stones will be laid on each side, the intervening space being filled in with the smaller stones and soil. About 6 in. from the ground the first 'throughs' should be laid, that is, long stones reaching from one side to the other. This will be repeated at 1-ft. intervals until the top is reached. The taper may be kept regular by a mould formed of wood.

If the stones lie upon the surface, and only require to be collected and carted, the cost per rod will be about 5*s.* for a wall of the height named. If, however, the stone has to be quarried it will necessarily cost much more. A quarryman will, if he be accustomed to the work, raise about 3 cu. yd. of rock and break it to suitable sizes in a day, the measure being taken from the space quarried. About 1 cu. yd., or load, will be required for 1 yd. of wall, therefore the following may be taken as the cost, the stone being quarried. Of course the cost may vary according to the standard of wages, but an expert builder should receive at least 3*s.* a day.

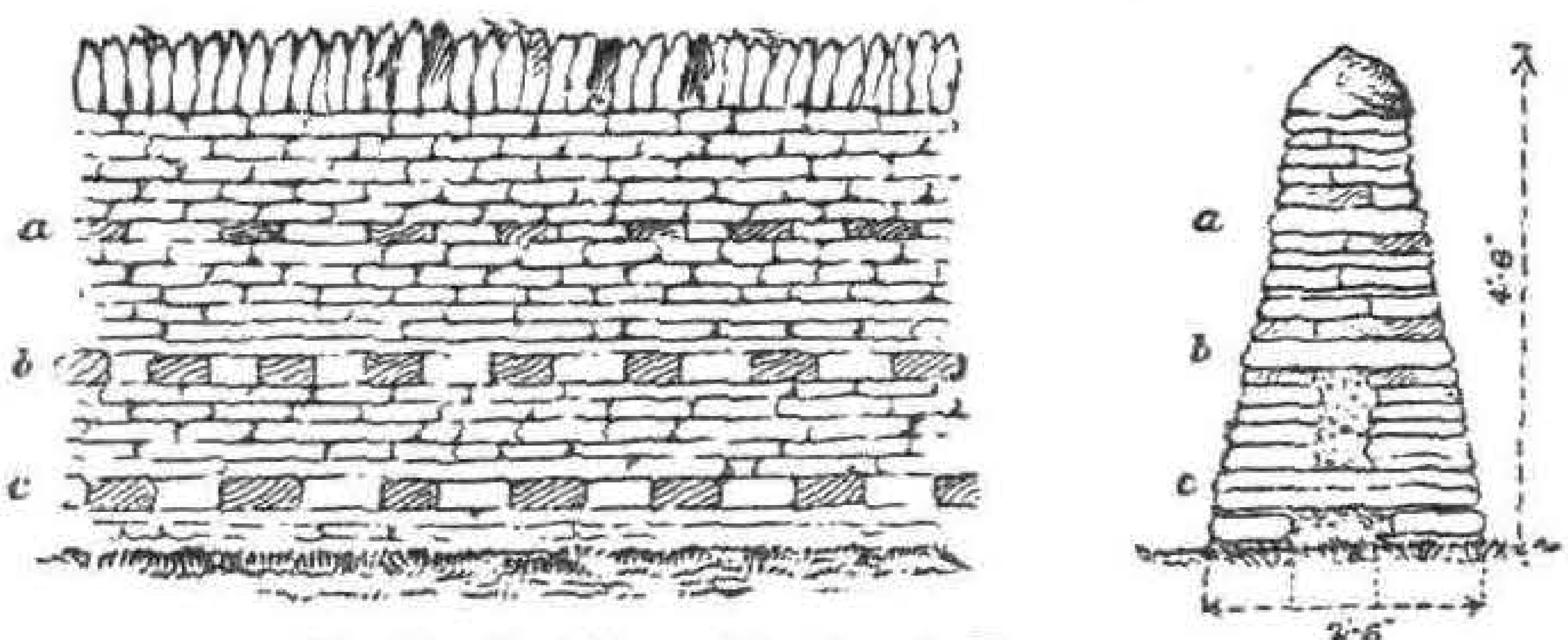


Fig. 13.—Elevation and Section of a Dry-stone Wall

	s.	d.
Quarrying 1 cu. yd. of stone, including— 'Throughs'	0	10
Building of wall	1	0
Cartage of stone	0	2
Cost per yard	2	0

The difference between the gathering of surface stones and quarrying is therefore great, practically doubling the cost.

A stone wall formed of boulders, or rounded stones, requires skill in building of a peculiar nature; and although such a wall may appear fragile, it is really both durable and effective. It is draughty, and from a distance appears to be pigeonholed. There is, however, a strength greater than would be supposed from its appearance. In the stone districts of Ireland, such walls 6 ft. in height are often seen.

Turf Walls.—Turf or other earth fences, though unequal in strength and durability to stone walls, are useful where stone cannot be obtained. If well made and cared for, they will last for many years, and with regular repair they may be considered permanent. They suffer naturally from the wear and tear of the elements, which necessitates occasional addition to the height; but so long as the base is sound and the coping in repair, they will maintain their efficiency. They are suitable in the reclamation of waste land where the turf has been undisturbed, and in the division of old pasture lands; but in arable districts their construction is manifestly impossible. The presence of a turf wall implies the presence of a double ditch, so that the space occupied will be very great; and this is the chief drawback to their use.

The points of consideration are: (1) That the width of the top should not be less than 15 in.; (2) the height should be not less than 4 ft. 6 in.; (3) the slope, or batter, should be quarter the height; and (4) there should be an escarp of 6 in. on each side. The top should be formed of turfs set vertically, and to consolidate it the seeds of creeping grasses may be sown. The height should be 6 in. more than the height intended, so as to allow of the sinkage which necessarily follows the building. If, then, these points are summarized, the space occupied cannot be less than 8 or 9 ft., allowing 2 ft. 6 in. as the width of each ditch. Over a long line of wall this means a serious loss of cultivable area, and one which will incur a loss of both rent and rates in addition to the loss in produce. Nevertheless there are compensating qualities, among them being the shelter afforded.

The mode of construction is much as follows: First mark out the bottom to the breadth required and remove the turf, cutting the sods to a uniform size and with a slope of 45 degrees. Leave the escarp of 6 in. on each side uncut, and then lay off the inner side and outer side of the ditches. From these, too, remove the turf, cut in a similar manner. These turfs will form the material for the building of the wall. The turfs are laid grass side outwards, in regular courses on each side, the space between being filled in with the soil taken from the ditches. Each course should be beaten firm with the back of the spade before proceeding with the next. The next course should be laid so that the joints break vertically with those below them. Care

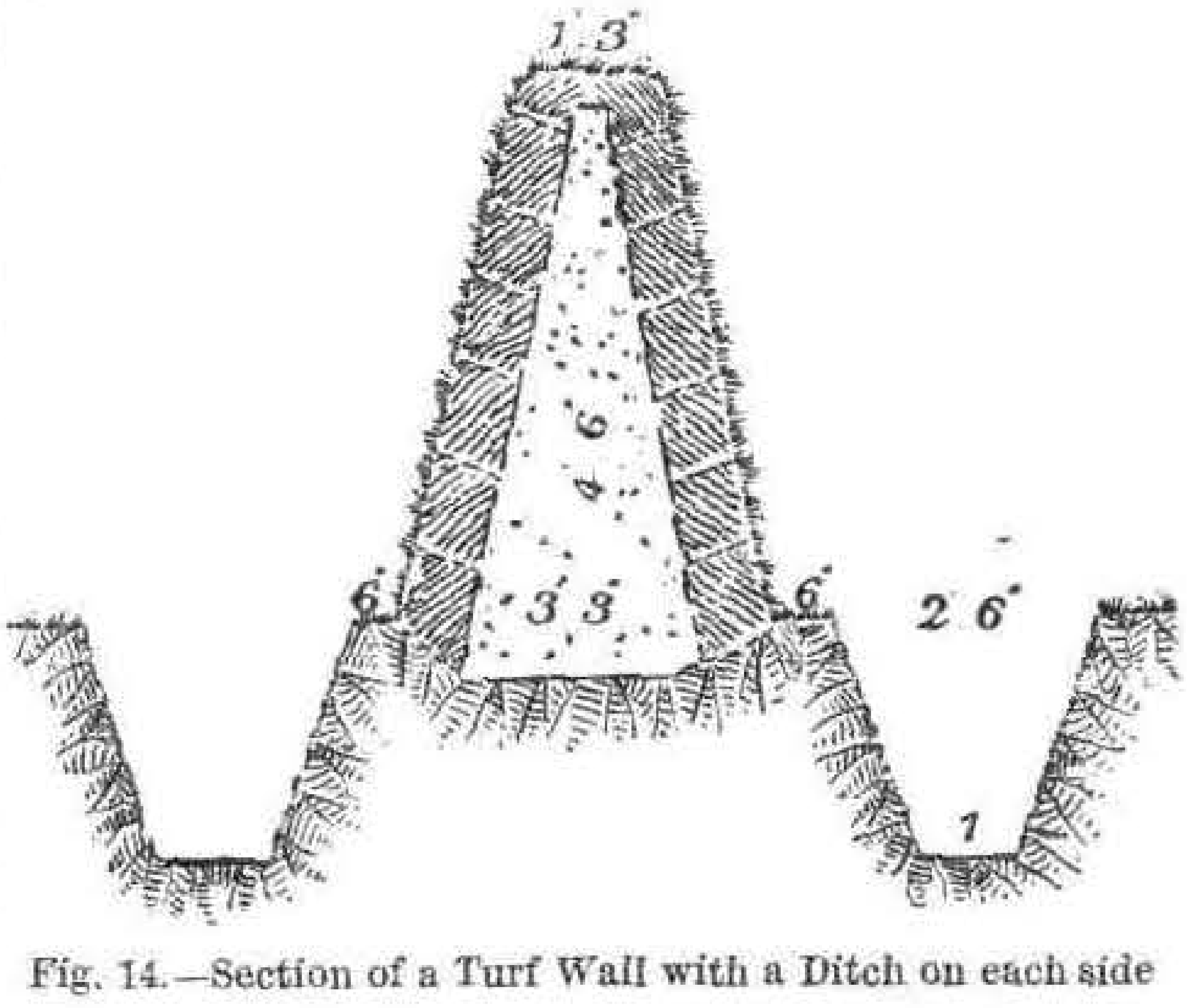


Fig. 14.—Section of a Turf Wall with a Ditch on each side

must be taken to keep the slope regular and uniform, and this may be done by use of a plummet applied to the face of the wall. The wall and ditches will proceed together, the one being necessary to the other.

Two men will be required to conduct this work, one working on each side; and the cost may therefore be estimated as follows: Two men will, if the conditions be favourable and skill efficient, build about 9 running yards in a day. If for such skilled work 3*s.* 6*d.* a day be

paid, the cost will be about $9\frac{1}{2}d.$ per yard, or 4*s.* 2*d.* per rod. It will be well to bear in mind that conditions are not always favourable, and therefore the cost may reach 5*s.* per rod. The ditches should be not less than 2 ft. 6 in. wide at the top, 2 ft. 6 in. deep, and 1 ft. wide at bottom. The strength of the wall will be increased if wooden pegs be driven through the turfs at intervals throughout the courses as the work proceeds.

Timber Fences.—There are many varieties of wooden fences—some durable, some temporary; none, of course, in the true sense permanent. Those fitted for temporary purposes have been considered under the head of 'Protection of Young Hedges'.

The best-known durable fences are formed of (1) British timbers, and (2) foreign timber of various kinds. The two questions in relation to these fences are durability and cost, with, of course, efficiency. The woods best fitted are oak, Spanish chestnut, and larch; but Scotch pine, spruce fir, ash poles, and foreign deals will make good fences. If the pine and fir be creosoted it will add some years to their duration; but if the supply upon the estate be ample for the purpose, it becomes a question whether it is worth while to adopt the process. Another question of importance is whether the oak and chestnut shall be sawn or cleft. There can be no doubt that the latter is best when it can be effected without undue waste, as by cleaving the grain is unbroken. When sawn the grain is cut through, and is therefore more exposed to the elements. It is not, however, every oak or chestnut which will cleave. On some soils both will cleave freely, whereas on others they will not cleave at all. Oak is undoubtedly the best timber for substantial and lasting fences, but chestnut, if free from shakes and well matured, will last almost as long, and it has, too, the merit of working more freely. These are points which must be settled by the parties concerned, according to the local conditions. *In the case of oak posts, whether for* gates, straining posts, or for mortising, the sapwood should be first removed from the part which is buried in the soil; and further, every post of importance should be sunk in concrete or chalk. The weakness of fences is often due to want of care in preparing and sinking the principal posts.

Post and Rail.—The best agricultural fence is the post and rail. The posts should be of oak or chestnut, sawn or cleft, 6 in. by 4 in., and 6 ft. 6 in. in length. The rails, also of the same materials, sawn or cleft, should be $3\frac{1}{2}$ in. by $1\frac{1}{2}$ in. in scantling, and 9 ft. 6 in. in length. This will allow of a 9-ft. panel. The posts should be mortised, the bottoms tarred, and sunk 2 ft. 6 in. in the soil, and be well rammed. It will strengthen the whole fence if a post of larger size be placed at intervals along the line of fence. Such posts may be 6 in. by 6 in., and 7 ft. in length. Four rails will be sufficient, placed, the bottom one at 9 in. from the ground, the second at 9 in. from it; and the top rail should be 4 ft. 3 in. from the ground, and the third halfway between. Halfway between the posts there should be a stake driven, 5 ft. 3 in. in length, with a scantling $3\frac{1}{2}$ in. by 2 in. This should be pointed and driven in until level with the top rail, and each rail nailed to it. A fence

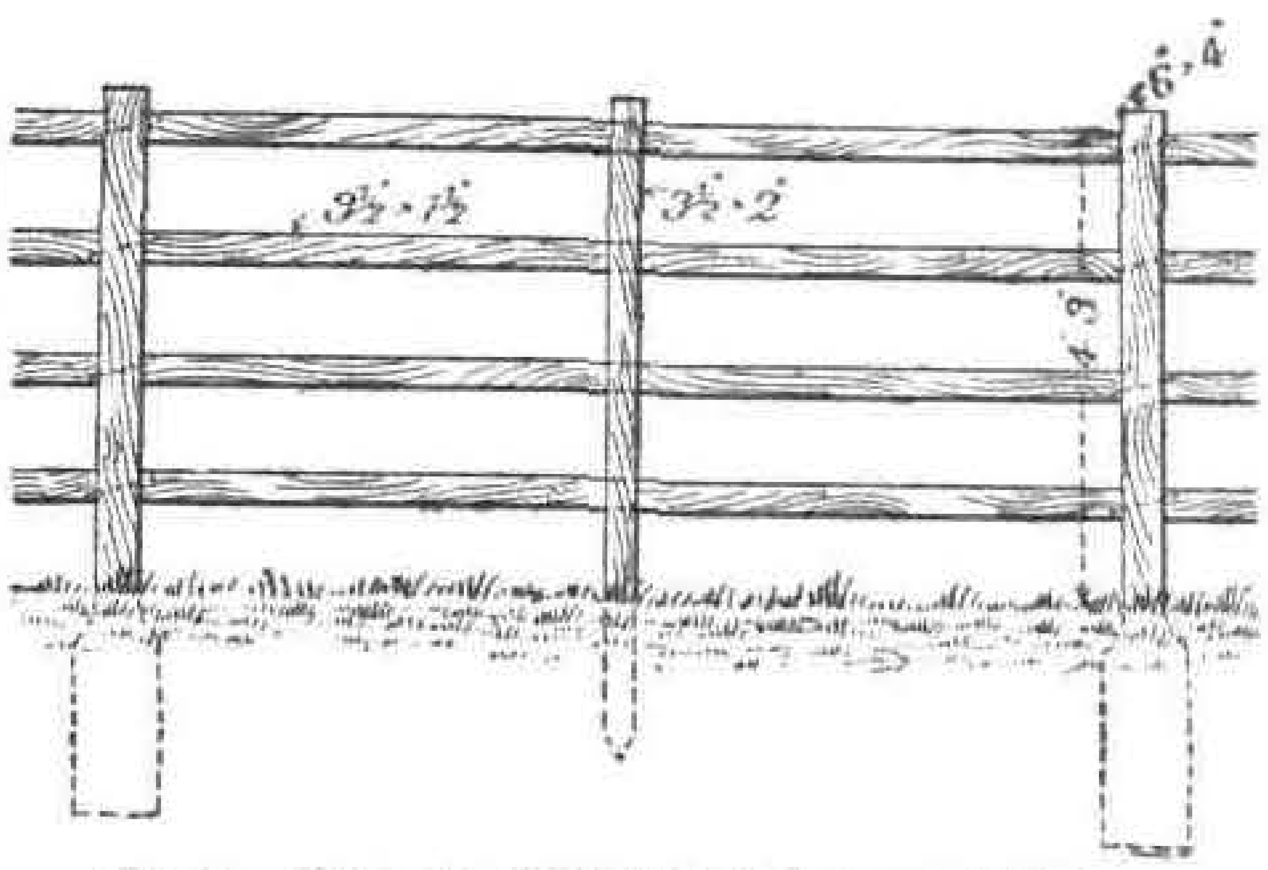


Fig. 15.—Example of a Panel of Post and Rail Fence

such as this, if kept in repair, will last for a full period, twenty to twenty-five years.

The cost of such will be:—

	s.	*d.*
1 post mortised and tarred	4	0
4 rails at $2\frac{1}{2}d.$ per yard, say	2	8
1 stump	1	0
Labour at 2*d.* a yard, and nails	0	7
Cost per panel	8	3
or, 2*s.* 9*d.* per yard.		

A light fence of the same kind, but with fir or larch rails, and three of them instead of four, can be erected at 1*s.* 6*d.* per yard; but in the long run the first will be the cheapest.

Park Fence.—By a park fence is meant a close or open paling of various heights. It is an

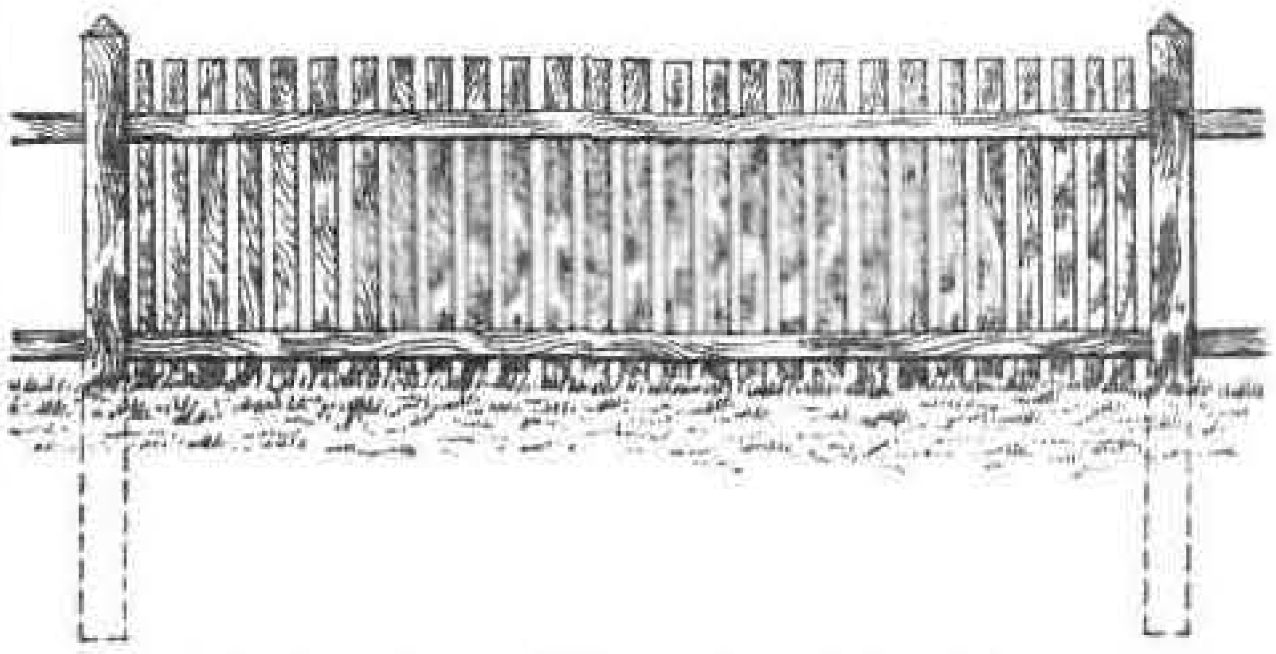


Fig. 16.—Example of an Open Paling Fence

expensive but a durable fence, and can hardly be looked upon as agricultural. It may consist of oak or larch, or the frame may be of oak and the pales of fir. If the latter, the pales should be creosoted. The construction, whatever the material may be, will be as follows: Open paling suitable for parks or gardens—posts 6 ft. long, with a scantling of 6 in. by 6 in.; two rails mortised into the posts, 9 or 12 ft. in length, with a scantling of 4 in. by $1\frac{1}{2}$ in.; and the pales 4 to 5 ft. in length (or according to the purpose), and 3 in. by $\frac{3}{4}$ in. wide, with a space of 2 in. between them. The material may be wrought or rough, the former if it is to be painted. The cost per yard for a simple fence will range from 2*s.* to 2*s.* 6*d.* If the whole be of oak, the cost will be more, probably from

3s. 6d. to 4s. per yard. The following may be taken as a guide, subject to the varying cost of material and labour:—

	s.	d.
Oak posts, 6 in. by 6 in. by 6 ft., at 6s.	6	0
2 rails, 9½ ft., 4 in. by 1¼ in., at 2d. per yard	1	1
22 pales, 3 in. by ⅝ in., 2 in. space, at 2d.	3	8
Nails	0	3
Labour	1	0
Cost per panel	12	0
or, 4s. per yard.		

The cost, of course, will increase with the height.

Close Park Paling.—The best fence of this description is that of oak, but larch pales may be used, or foreign deals. It will not be wise to use home-grown fir. An excellent substitute is one or other of the Australian gums, as there is every reason to believe that it will prove as durable as oak. In erecting a costly fence of this kind, care should be taken to adopt every means to secure efficiency and durability. With the exception of a brick or stone wall, there can be no more permanent fence than this. The height may be from 4 ft. 6 in. to 6 ft., according to local conditions and purpose; but whatever the height the method of construction will be the same. There is one point which we consider worthy of consideration; it is, that in place of the gravel board there should be brickwork of three or four courses. The posts should be rammed in with chalk, or with concrete, which is better; and further, all sapwood should be removed from the wood below the ground. It is those details which give life to the fence. The face of the fence, if it be on the boundary, should face the neighbour's land. The pales may be sawn or cleft, but the latter is best, if the oak will cleave into such lengths without waste.

The cost of such a fence is considerable, ranging from, say, 6s. to 9s. per yard of length, according to height and scantlings. Taking for an example a height of 5 ft., the details will be as follows: Posts fixed at 9 ft. apart, centre to centre, three cant rails; gravel board (or wall); pales close and overlapping; and galvanized nails. Posts 8 ft. in length, scantling 6 in. by 5 in., gravel board 11 in. by 1½ in., pales 4½ in. wide, overlapping 1 in. The gravel board will be sunk to a level with the face of the fence. If the whole be of oak there will be no occasion to tar, creosote, or varnish, but if of other material it will be wise to do so.

	£	s.	d.
Oak post, 8 ft. by 6 in. by 5 in. ...	0	8	0
3 cant rails, at 3d. per yard of length	0	2	3
Gravel board, 9 ft. by 11 in. by 1½ in., at 9d. per sq. ft.	0	6	2
30 pales, at 2d.	0	5	0
Nails, say	0	0	6
Labour	0	3	0
Cost per panel of 3 yd. ...	1	4	11
or, 8s. 3d. per yard.			

Sundry Temporary Fences.—There are many kinds of wood fences more suitable for the filling of gaps, or for short lengths, which it is only necessary to name.

The 'Scotch fence' is useful as not being readily crossed, and so may be useful to prevent trespass. It may be of any reasonable height, say from 3 to 4½ ft. It consists of small poles of larch, such as are obtained from thinnings of plantations, or of other poles which may be straight and otherwise suitable. These are driven in at intervals of 8 in., more or less, and upon the top of them a rail of larch is fixed, being bored to receive each upright. A nail here and there keeps the whole firm. If the points of the stakes are tarred, such a fence will

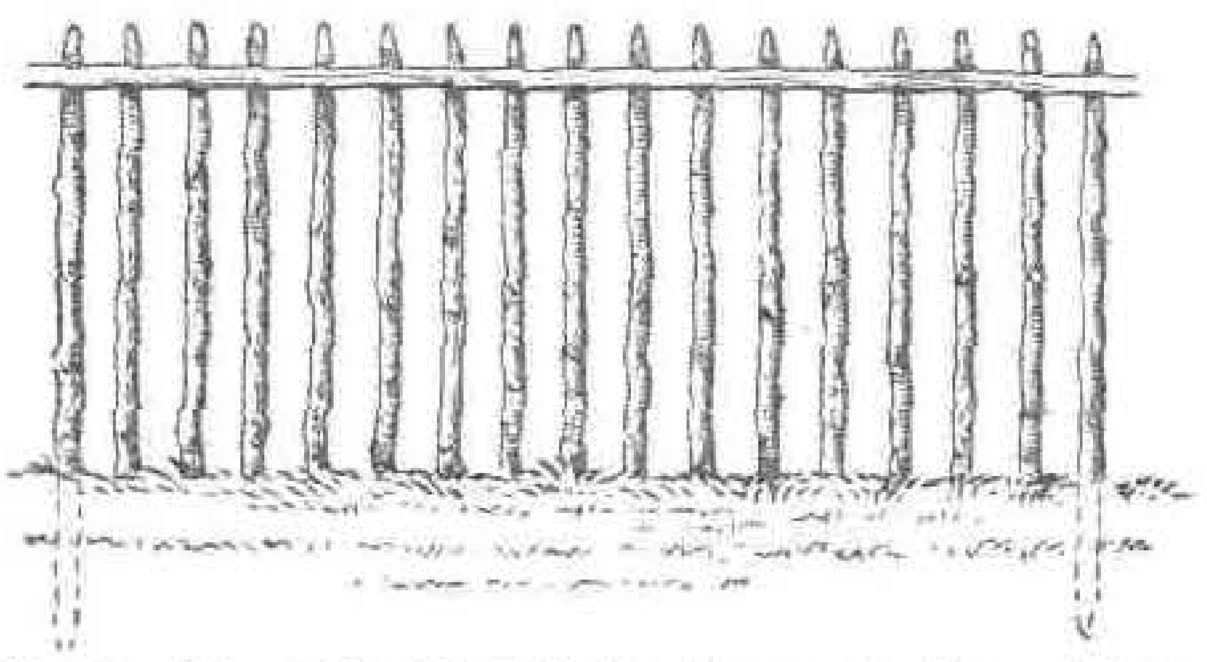


Fig. 17.—Example of Scotch Fencing made of Larch Poles

last for many years. It should be borne in mind that such a fence is more suitable in a larch district than elsewhere, as such poles lend themselves to the style better than any other. The cost of such a fence, if of larch, will be about 8d. a yard.

Another form of fence will be of ash, larch, or other pole suitable, driven in at intervals of 4 ft. 6 in. Upon these, rails of the same material, sawn or whole, are nailed. Such a fence, 3 ft. to 3 ft. 6 in. in height, with three rails, will be found both simple and useful. They will, of course, be formed of whatever poles the estate

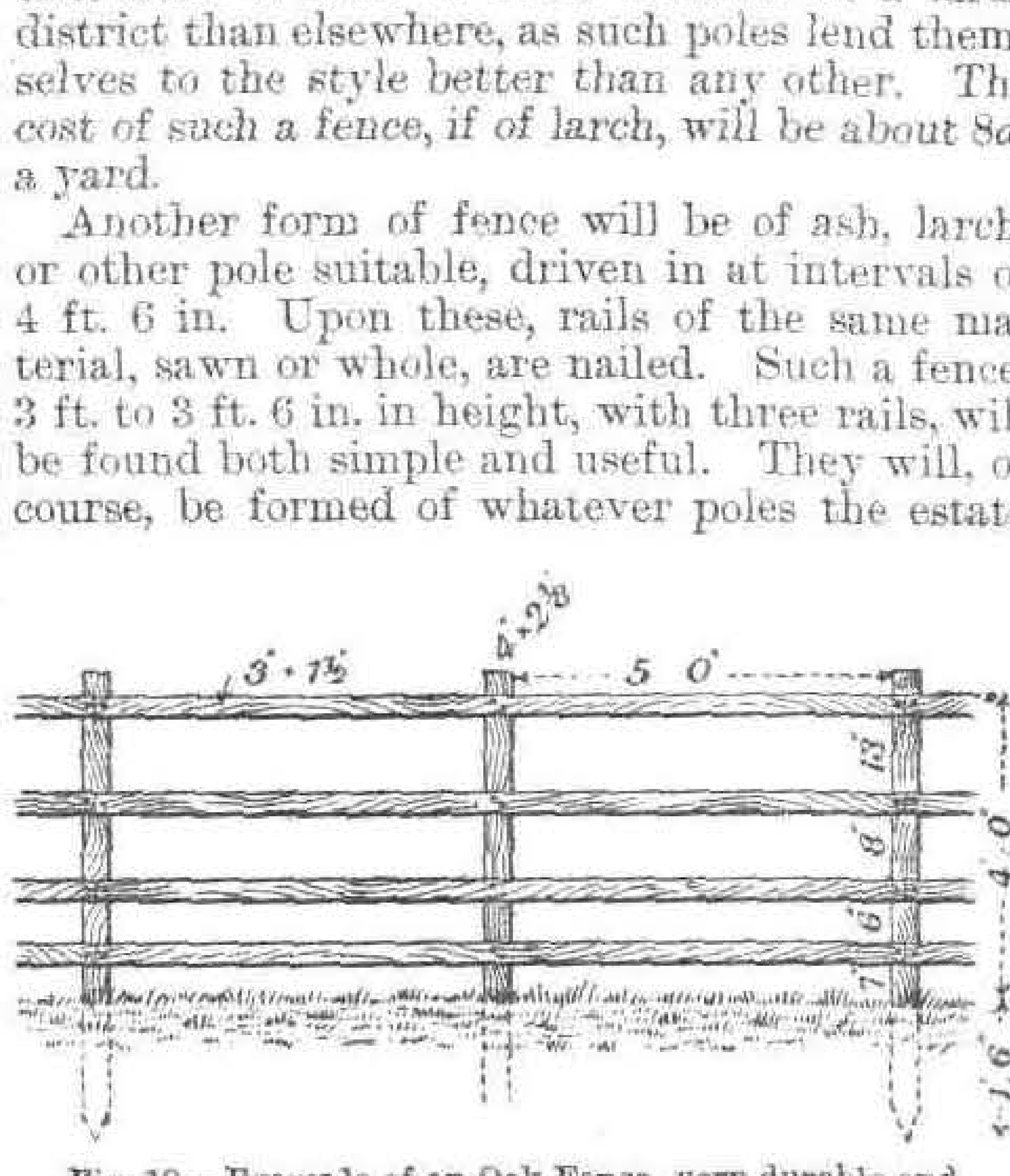
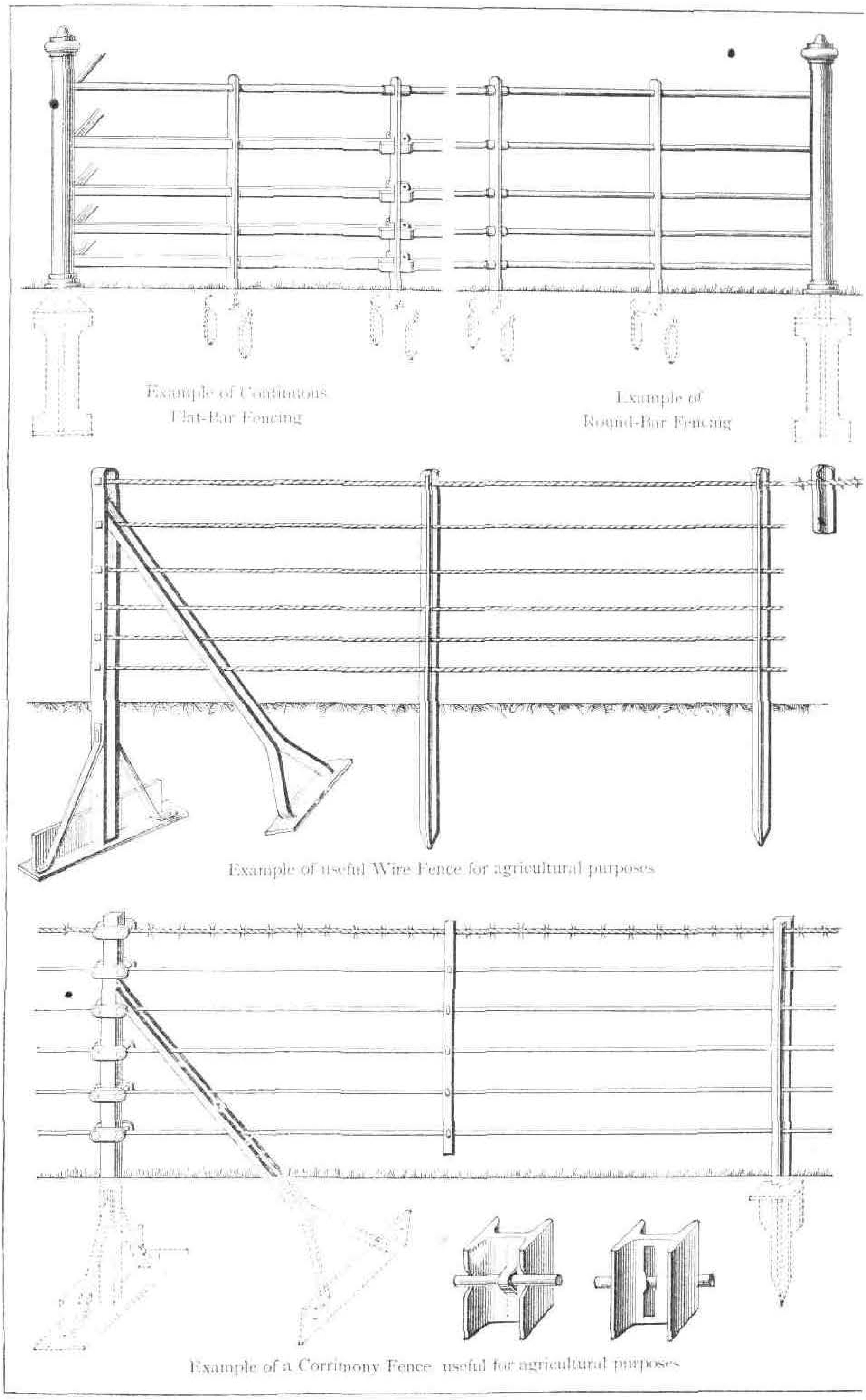


Fig. 18.—Example of an Oak Fence, very durable and *efficient*

can supply. Some estates can produce larch, others ash, and others chestnut; and each and all are fitted for the purpose. The rails may be of small poles, whole, or if of larger size, sawn down the middle. The latter will make the firmest fence. Such fences will not resist heavy cattle for many years, as the stumps are liable to decay; but an occasional replacing of these will render it safe for a longer period. A strong fence, however, of a similar character may be made of sawn oak, and the following details taken from such a one may be useful: Height of posts, 4 ft.; height of top rail, 3 ft. 10 in.; 4 rails, at the following intervals between, of 7 in., 6 in., 8 in., and 13 in. respectively, from the



EXAMPLES OF IRON FENCES

ground upwards; posts 5 ft. apart from centre to centre; posts 5 ft. 6 in. long, pointed; scantling, 4 in. × $2\frac{1}{2}$ in.; rails, 10 ft.; scantling, 3 in. × $1\frac{1}{2}$ in. All the posts are driven, and the rails nailed to them. The estimated cost of such a fence is 1*s.* 3*d.* to 1*s.* 6*d.* a yard. This will resist the heaviest cattle, and last without repair for many years. The rails being close together at bottom, will keep back both pigs and sheep.

A Dead Hedge.—A dead hedge is one consisting of brushwood, or one with so small an amount of live wood as to be of no real importance. It consists usually of hazel, blackthorn, whitethorn, privet, or of mixed coppice wood. Stakes are driven in at 2-ft. intervals, and rods are woven between them, the whole being bound together by a hether of privet, willow, or other pliable rod. The hedge will have a plain and a brush face, and the brush face should lie toward the pasture side if the fields divided are arable and pasture. A ditch on one side is usual, as if there be none it is questionable whether such a fence is desirable, because the pressure of stock which may be brought against it will be so great as to break it down, especially when it has stood for a year or two. A complete dead fence of this character is naturally of less strength than one in which there is some live wood. A few living stakes and rods help to bind the whole fabric. To erect these in a substantial manner, men accustomed to the work should be employed; for a novice will fail to give it the pliable strength so essential to its durability. These brushwood fences are found in many districts, and when new they possess great strength; but the life of such is short, and the cost is quite out of proportion to the benefit obtained. The cost of labour will range from 8*d.* to 10*d.* a yard according to substance and quality.

The following details are for work actually done in the midland counties: 2 men at 2*s.* 4*d.* a day. work performed, $1\frac{1}{2}$ rod a day; 1 load of thorns is required for 3 rods of length; horse labour, 5*s.*; labour only, 5*s.* 6*d.* per rod, task work, and with material, 7*s.* per rod. This was for a fence of unusual size and strength. The dead wood of the old fence and the faggots of the surplus live wood were given to the men and drawn free by the estate. This perquisite was afterwards withdrawn as being excessive.

Iron Fences.—Iron fences are at once substantial, durable, and neat in appearance. The initial cost is somewhat large, but little annual cost will be incurred in their maintenance. The best known of this material are the continuous flat-bar, round-bar, and tubular fences, and from an economic point of view there is little to choose between them. Another form is that of hurdles, the merit of which lies chiefly in the fact that they are readily set up, and as readily taken down. Owing to this, they may be used for temporary purposes. These fences will resist the pressure of the heaviest cattle, provided they are of sufficient height to prevent the cattle from reaching over. If set up between arable and pasture fields, we have found it well to dig a ditch on the arable side, as it prevents interference when ploughing. It will be well when measuring the length of fence for the placing of the order, to test the accuracy of the chain. Chains in long use are apt to stretch considerably, and the result may be an insufficient length, which may lead to delay. To keep these fences in good repair they should be occasionally cleaned, oiled, and varnished, and at the first setting up this should be provided for in the contract. Oiling should always precede varnishing. It is impossible to state the life of a continuous iron fence; but if care be taken, if the foregoing advice be adopted, then it will run into many years; and from a practical point of view it may be called permanent. The colour may be natural, that is varnished only, or it may be painted white or green according to taste. The latter colour is useful where it is desired to secure a wide and unbroken view over park land.

Continuous Flat-bar Fencing.—For farm purposes, or for woods and plantations, the simple flat-bar fencing meets the requirements well. It is simple of construction, easily put up, and becomes immediately effective. It can be set up by an unskilled man if he be intelligent and methodical. It consists of four or more flat bars and a top round bar. Terminal pillars are supplied at prices varying from 8*s.* to 18*s.* each, according to height and substance. The uprights, which are placed at intervals of 3 ft., are sunk 14 in. into the ground, and may be pronged or simply pointed. On light land, in the latter case, earth-plates are recommended; but on heavy such are not required. The size depends upon the height, and ranges from $1\frac{1}{4}$ in. by $\frac{1}{4}$ in. to $1\frac{1}{2}$ in. by $\frac{3}{8}$ in. The standards which receive the joints are larger. The top bar is round, and the usual size is $\frac{5}{8}$ in. The lower flat bars are 1 in. by $\frac{1}{4}$ in., and are made to overlap at the joints, and are kept secure by wedges supplied for the purpose. The bars are notched at the bottom to fit upon the standards. The cost of the above ranges from 2*s.* to 2*s.* 10*d.* per yard at the works. To this must be added the cost of carriage, erection, and varnishing. The former will vary according to distance, but the latter will vary from 4*d.* to 6*d.* per yard. A fence recently erected, 3 ft. 9 in. in height, has cost 6*d.* per yard to erect; but this included putting up, cleaning, oiling, and varnishing, and tying on and sinking wire netting. The cost of such a fence, therefore, cannot be less than 3*s.* per yard. If earth-plates be used, it will cost 3*d.* per yard more, and if protected on the arable side by a ditch a further 1*d.* to $1\frac{1}{2}$*d.* may be added. (See illustration on Plate.)

Round-bar Fencing.—There is little to choose between this and the foregoing. They are both equally durable, the cost is much the same, and so far as appearance is concerned the one is as neat as the other. It is obviously a matter of taste. There have been many improvements introduced to give strength, and to add to the appearance; but these seem to lend themselves more to parks and pleasure grounds than to divisions of fields for agricultural purposes. (See illustration on Plate.)

Iron Hurdles.—These are useful, as before stated, for temporary purposes or for short lengths, but are not applicable to long lines

of fencing. Due to constant lifting and re-setting, the life of such a fence is lessened, and this, necessitating as it does continual repair, renders *the selection of it of doubtful economy.* Nevertheless these hurdles have their uses.

The cost of a 5-bar hurdle for light cattle will vary from 3*s.* 6*d.* to 4*s.* 6*d.* each, which will be equivalent to 1*s.* 9*d.* and 2*s.* 3*d.* per yard. For

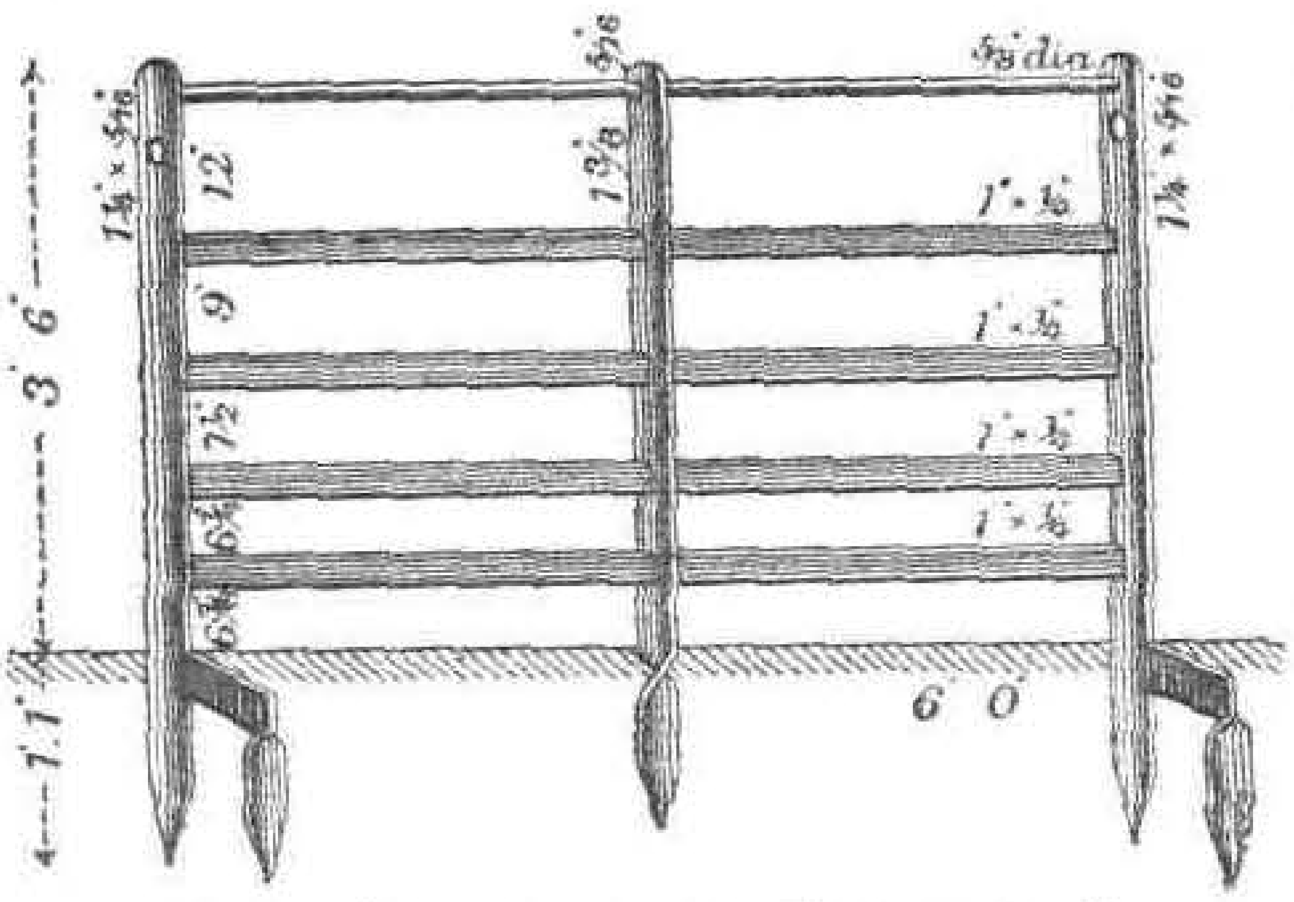


Fig. 19.—Example of an Iron Flat-bar Hurdle

heavier cattle the hurdle should be stouter, and will therefore cost more.

Strained Wire Fencing.—For farm purposes this class of fence is one of the most useful. *It is easily put up, and with proper care it is* both durable and efficient. It has the merit of simplicity, as it can be put up and taken down by labourers if directed by a competent foreman. The most simple form consists of wooden or larch straining posts, and *solid iron wire;* but the more elaborate forms supplied by makers will be better fitted for parks and pleasure grounds. There are several kinds of wire—

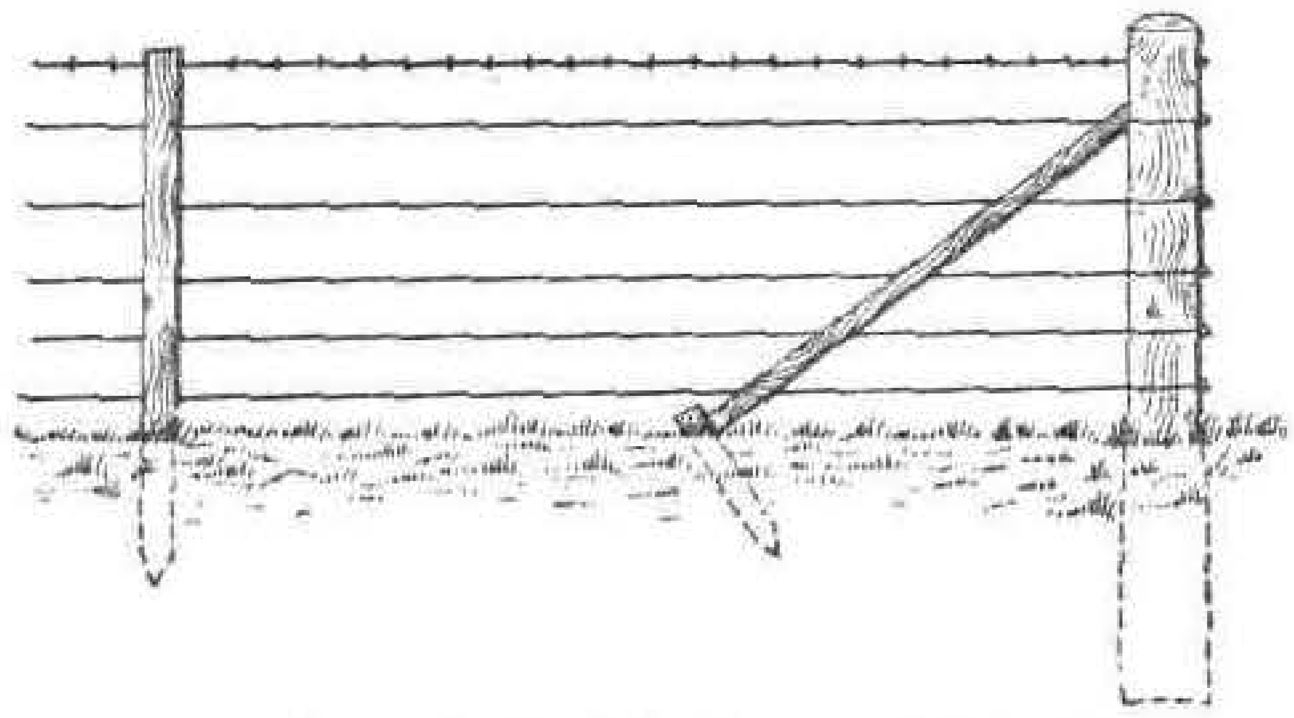


Fig. 20.—Example of a Wire Fence with Wood Posts

black-rolled, solid iron, steel, and strand wires. The best probably for ordinary purposes will be solid iron, drawn and annealed.

There are *eight gauges, and No. 4 may be* taken as the most suitable in iron, and No. 6 in steel; but the lower wires may be of less gauge. Straining posts of oak or larch should be placed at not less than 100 ft. apart, and *stakes of the same material at 9 ft. apart.* Six wires will prove the most efficient fence, but five will serve for horses and cattle. It may add to the efficiency if the top wire be barbed; but there are many objections to this barbarous method of preventing trespass. The points to *bear in mind are—that the staples should not* be driven close, so that at any time the wires may be re-strained without withdrawal of them; *and the employment of some straining appliance attached to the straining posts* will facilitate this. Stays where required will give fixity. It may lessen the initial cost if the posts be placed at 12 ft. apart, and a stump driven between them. The difference in cost will lie be*tween the value of a sawn post of larch or* oak and that of a coppice stump; but the economy will be a doubtful one. Any wood employed, except oak, should be creosoted.

The following may be taken as the initial cost of a *simple farm fence 3 ft. 6 in. in height*:—

		£	s.	d.
1 oak straining post, 8 in. by 8 in. by 5 ft. 6 in.		0	8	0
11 oak posts, 4 in. by 4 in. by 4 ft. 9 in., at 6*d.*		0	5	6
2 stays at 1*s.*		0	2	0
2 wires, No. 4 = 269 yd.	at 14*s.* ...			
3 ,, ,, 6 = 393 ,,	at 14*s.* ...	1	8	0
1 ,, ,, 7 = 467 ,,	at 14*s.* ...			
Staples		0	1	0
Labour at 3*d.* per yard		1	5	0
Cost per 100 yd.		3	9	6
or, 8½*d. per yard.*				

If galvanized 7-ply strand wire be used, the cost in respect of the wire will be increased by 7*s.* per cwt.; but Nos. 6 and 7 will extend to a greater length, so that the extra cost will not be much. Some prefer it, but we are of opinion that solid wire is better for farm purposes. Galvanized solid wire has the advantage of not rusting, and it may be obtained at the extra *cost of 2s. per cwt. These are all matters of* opinion and taste; but cost is important in everything relating to agricultural land, provided it is considered in the light of full efficiency.

The above details apply only to ordinary farm fences. For more important purposes, that is, where effect is of importance, the various kinds as recommended by makers are worthy of consideration. The cost will range from 1*s.* to 1*s.* 6*d.* per yard. A useful and substantial fence is *illustrated in the accompanying Plate.*

Another form of wire fence is that known as 'Corrimony pattern'. It consists of angle-iron standards, set up from 12 to 22 yd. apart. In the intervening spaces the wires are kept in position by 'droppers' fixed at 6 ft. apart. The standards are sometimes notched to admit of the wire without threading. The figure on accompanying Plate will render this method plain. It has the advantage of cheapness, but it will be found lacking in fixity.

If the top wire be barbed, as shown in the Plate, it will to some extent overcome the fault of slackness. The cost of this fence complete will range from 9½*d.* to 1*s.* per yard.

Stiles.—Due to rights of way and to the pass*age of labourers to and from their work, stiles are necessary and economic, in that their* presence prevents the making of gaps. Much injury is caused to fences, especially live hedges, by pushing through so as to avoid a circuitous path, and, so far as possible, this should be rendered *unnecessary by the erection of stiles or hand*

gates at every point of ingress and egress. It may be taken that stiles and gates well placed add to the life of every fence. There are many kinds in use—the simple bar stile, the V-shaped opening, the gate and bow, and hand gates. These are best shown by the accompanying figures: If the passage crosses a wire fence, with

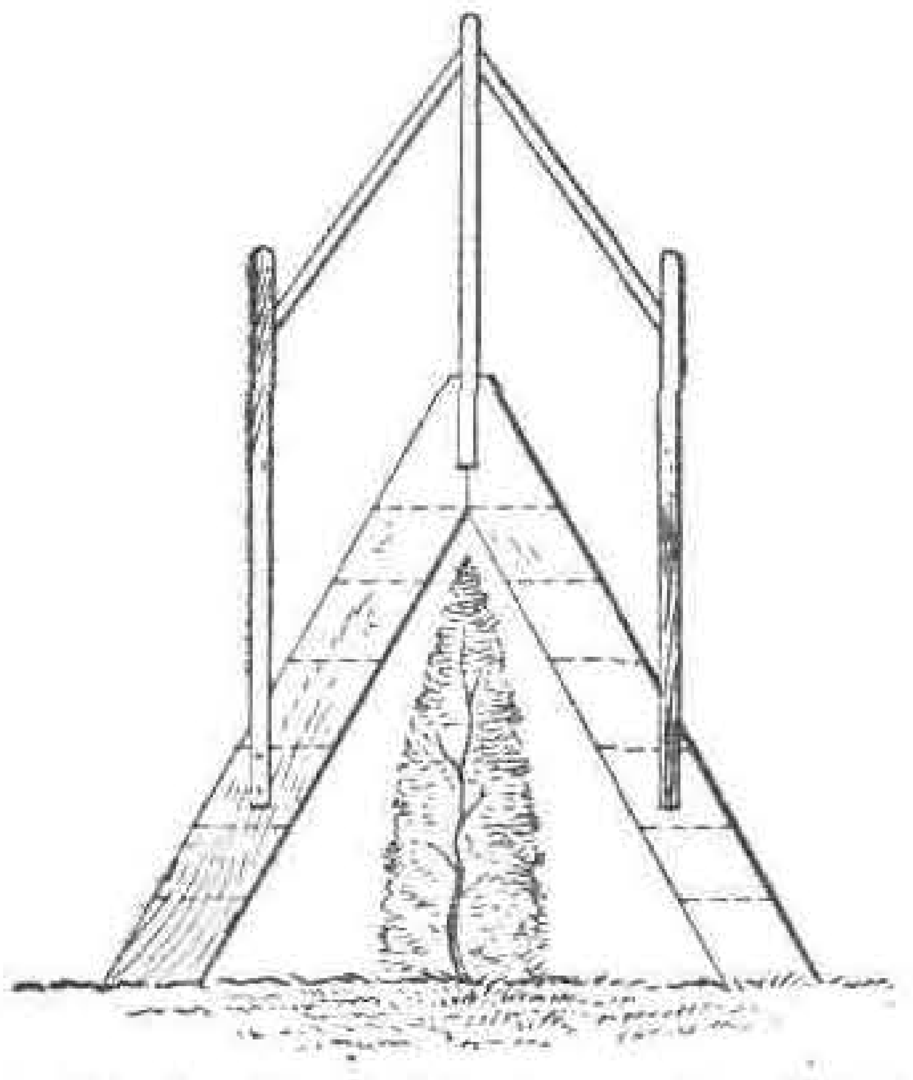


Fig. 21.—Wooden Step-ladder for crossing High Fences

or without netting, it may be met by a wooden bar fixed to the top wire, with a step, or two steps, correctly arranged; or by a double ladder so fixed as to secure the fence from injury. These ladders should be rendered movable, but be fixed while in use. The steps of such ladders, if of wood, should be in rounds, not flat, as the latter holds water and leads to early decay. If a handrail be attached, it will be found a safe and easy method of crossing a difficult fence. Iron ladders can be purchased and fixed, at from 30*s.* to 35*s.*

If the fence be a hedge, there can be no better stile than a simple bar with steps. The points to

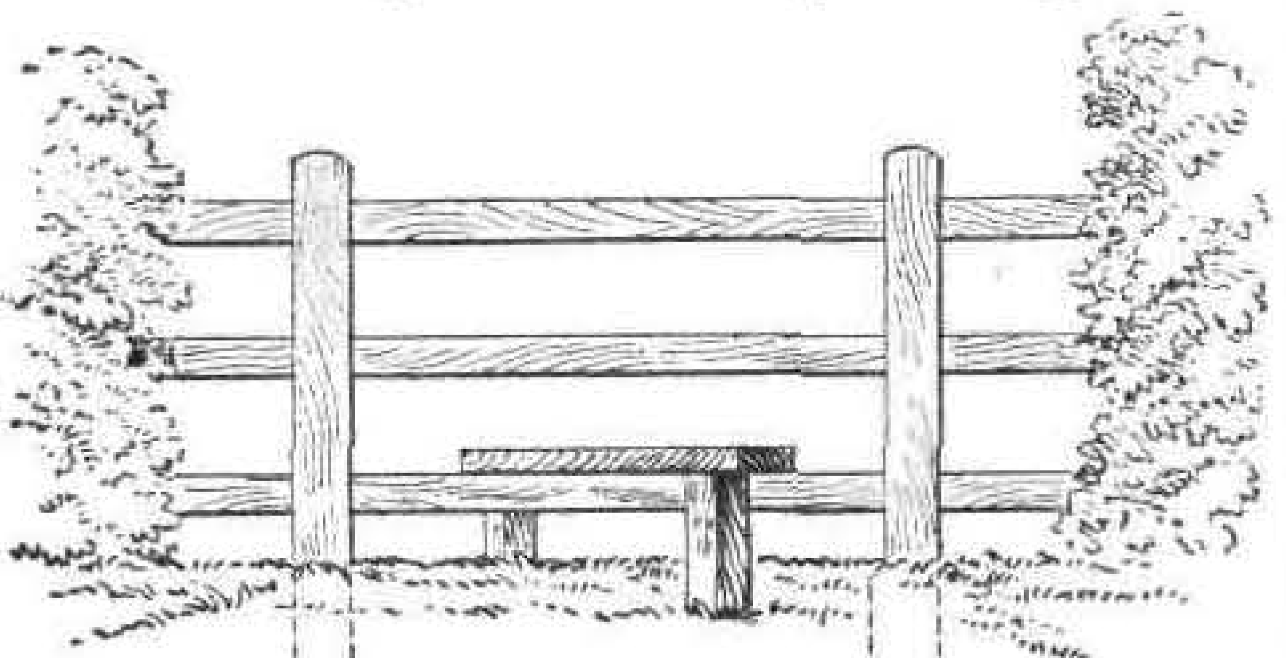


Fig. 22.—Bar Stile, suitable for all purposes, except for Fences of Iron or Wire

ensure success are—ample width, so as to prevent the brushing of the hedge on both sides; sufficient height to prevent trespass by cattle; and strength of structure and material. If over 3 ft. in height there should be one step; if exceptionally high, two will be necessary. It is wise to make stiles easy, as it leaves no excuse for avoiding them. The top bar may be of sawn timber, say 4 in. by 2 in., or in the round.

A V stile, though at one time frequently adopted, is now in less general use. In some districts it is still common, but it is not so universally used as it might be. It has its advantages and disadvantages. There is always the possibility of trespass by sheep, and even young cattle; and, on account of the dragging of women's dresses, it is sometimes avoided, and a gap made. Such stiles are best made of oak possessing a suitable natural bend, and there should be one crossbar at the bottom. A short bar panel upon each side will help to protect the hedge.

Another form is that of the semicircular bow, or triangle, which will be best understood by

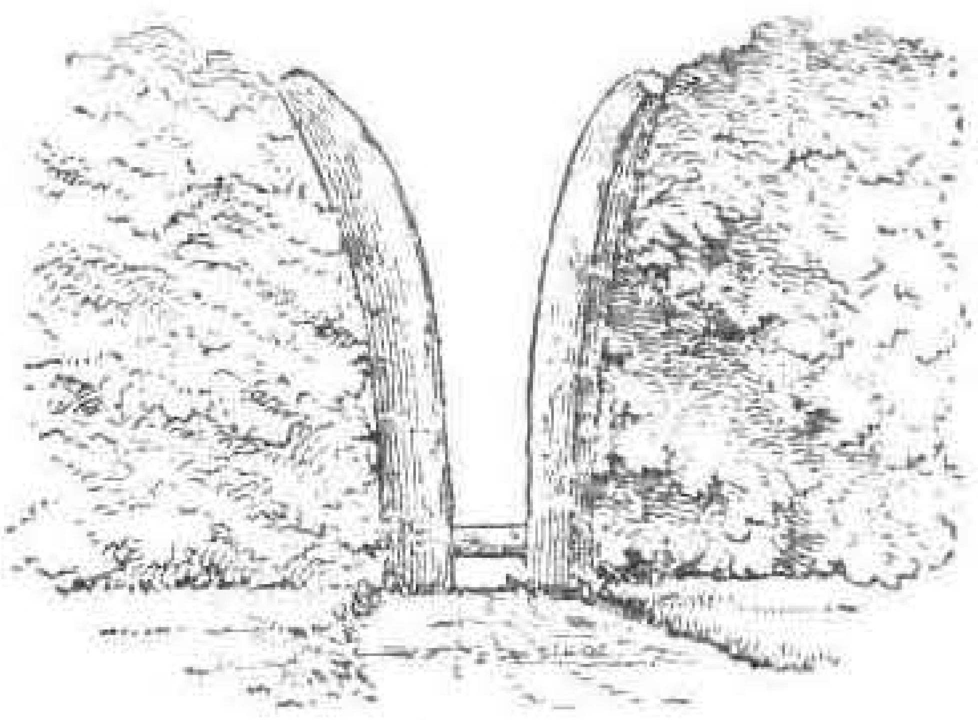


Fig. 23.—Simple V Stile

reference to the illustration. It is formed by one straight panel, facing which is a semicircular or triangular structure at a right angle to it. This renders the passage easy to foot passengers, but impossible to cattle. In stone districts this method is often adopted, flat stones on end being substituted for wood. It possesses the merits of cheapness and simplicity. Another and simple form is an iron hurdle, fixed, with steps of wood.

Hand Gates.—If these gates can be so fixed and arranged as to prevent the trespass of cattle, they are undoubtedly convenient. It is, however, quite impossible to expect the general public to close them carefully as they pass through, so that some automatic method of closing must

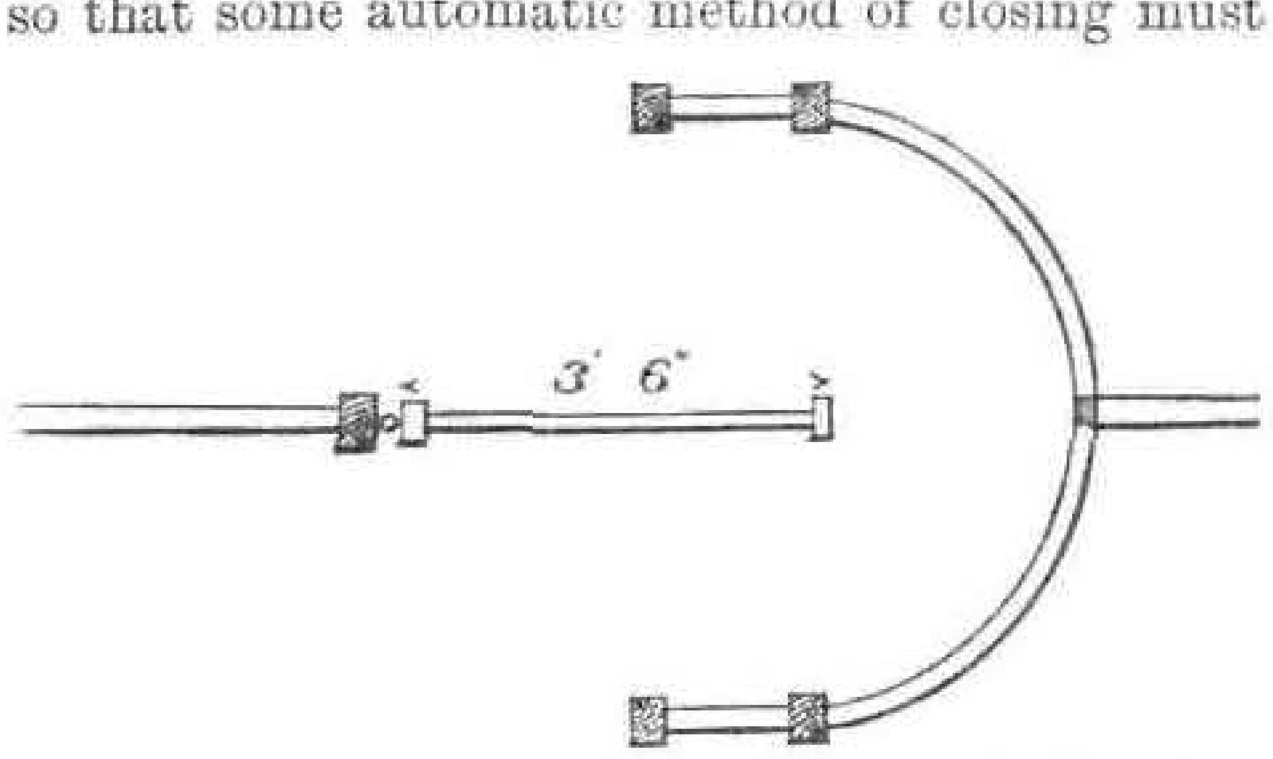


Fig. 24.—Plan of Gate and Bow. If preferred, the gate may be a fixed panel, as shown.

be adopted, and even this is liable to get out of repair. Persons connected with land management know well how difficult it is to secure efficiency in respect of this. Self-closing may be secured by so hanging the gate that it will both close and catch, but the slightest injury to posts or gate will render this ineffective. The best plan will be to erect a semicircular bow, in which the gate will swing, as described in the foregoing section. *If it should be necessary to open* fully, an appliance can be attached which will

render this possible; but in this event the gate is best made of iron. A joint of a few inches, readily fixed or opened, sufficiently wide to allow the gate to fall back will secure this. Such gates can be purchased and fixed for from 40*s.* to 50*s.*

If of wood, as in the figures, the same method of construction can be adopted, but there will not be much saving in cost.

Hunting Gates.—The adoption of hunting gates in such places where the hunt customarily resorts is a wise provision, and one which tends

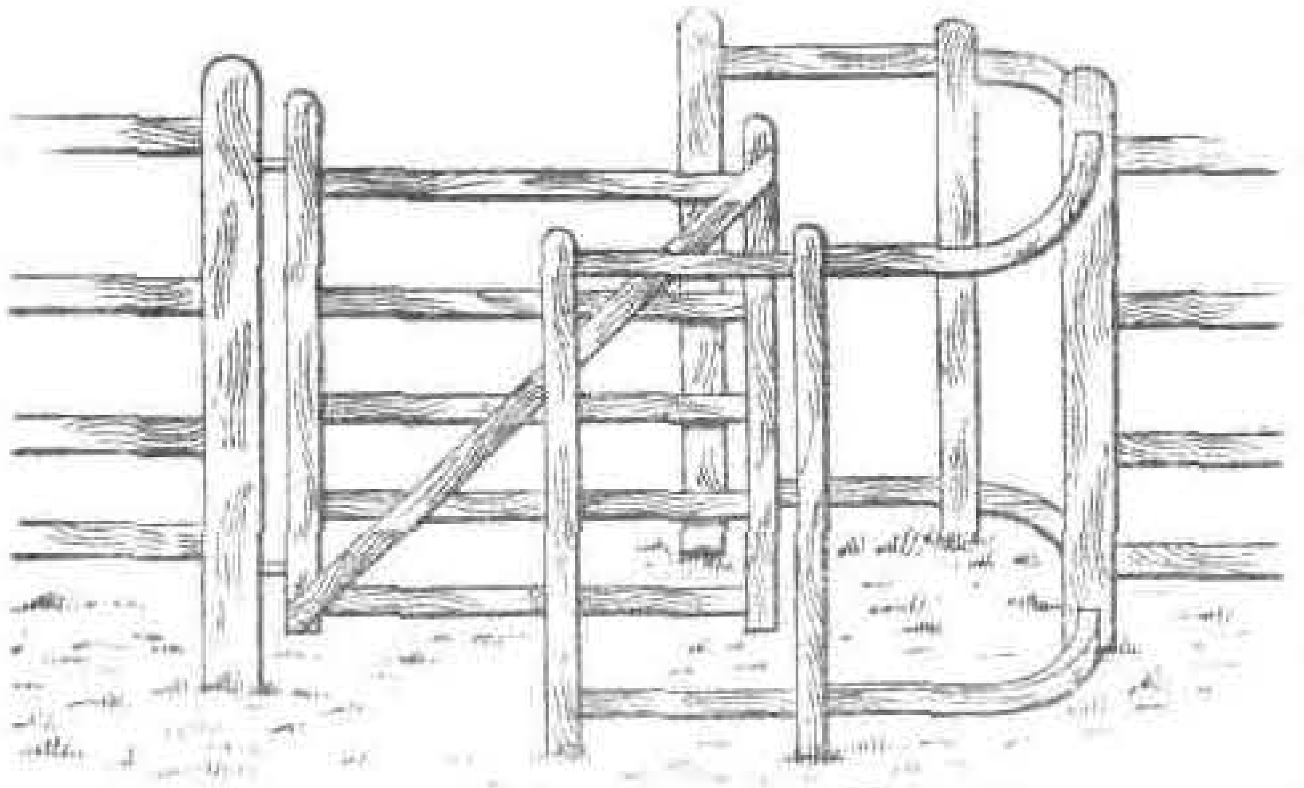


Fig. 25.—Hand Gate and Bow

very greatly to the preservation of hedges and other fences. If painted white so as to attract the eye, the effect will be still more apparent. The points to bear in mind are: (1) a sufficient width for a horse, say a minimum of 4 ft. 6 in.; (2) a height readily reached from the saddle; (3) a tapering of the structure from the hinge end to the head, so as to ensure an easy swing; and (4) a catch which will prove effective. The cost of these complete, whether of wood or iron, will be about 60*s.* to 70*s.*

Field Gates.—Gates are necessary in certain places in almost every hedge or other fence, and

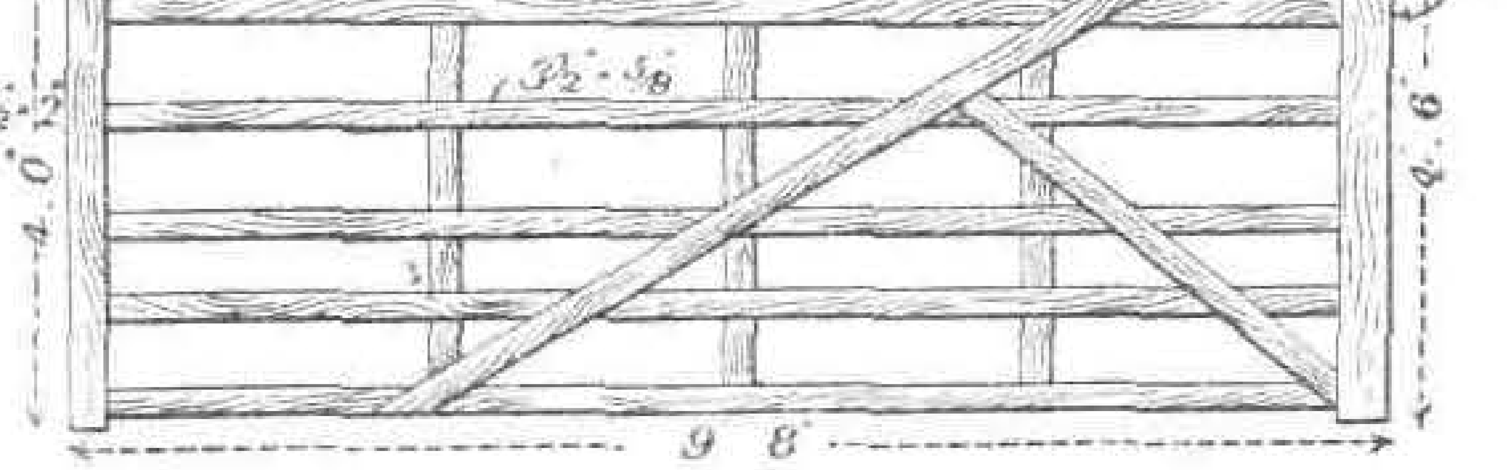


Fig. 26.—Example of a Field Gate suitable for Simple Farm Purposes

these should be of such a character as to ensure durability and efficiency. Too often gates are so neglected that they not only cease to be effective, but serve as the chief point for trespass.

The points to bear in mind are—strength, durability, free swinging, and perfect closing. The first two are met by choice of material, and the rest by construction and skill in hanging. *There is nothing which shortens the life of a gate more than forceable clashing against the post, and dragging at the head.* The first is due to unskilled hanging, and the second to want of verticality in the hanging post.

The art of hanging a gate consists in attention to the following points: (1) A substantial hanging post, well rammed with chalk, or set in concrete, and perfectly vertical; (2) a firm riding-hook at the heel, and a hanging-hook bolted through the post. The set of the hinges and hooks will determine the swing and closing of the gate.

The hanging post should be free of sapwood, as this decays and the post becomes infirm. It should be sunk at least 3 ft., and the soil taken from it should be cast aside if chalk can be obtained. Concrete, however, is the best material, both for steadiness of support and for durability. The size of such a post should be 11 in. by 11 in. by 7 ft. 6 in. if for a heavy gate, or 8 in. by 8 in. by 7 ft. if for an ordinary field gate. The striking posts may be respectively 9 in. by 9 in. and 7 in. by 7 in. Both should be planed and wrought if the timber be other than oak, as *paint will be found a great preservative. Oak* posts may be painted or not according to taste. Sweet chestnut, if procurable, makes an excellent post, and it will be found as durable as oak, provided it is free from 'shake'. Oak nevertheless stands as the ideal gate post. Larch posts, if charred or tarred, are suitable, provided the gates hung upon them are of pine. A point of importance is that these posts should not be used for the straining of wire. The strain draws them out of position, and the swinging of the gate will be deranged. Many landowners adopt one design of gate throughout their estates, and as such plan is indicative of ownership it is to be commended. Such gates will be of one design, one colour, and one method of hanging: and if the clerk of works undertakes the setting up and keeping in repair of all, it will tend to the welfare of the estate. We offer this suggestion to those concerned. If repair of gates be left to each individual farmer, there will be constant neglect and ultimate loss. Farmers *are of course liable for repairs through* their covenants, express or implied, but though this stipulation is easy of fulfilment in theory it is difficult in practice. It would add materially to efficiency in this respect if each gate upon an estate was numbered and chronicled. The main points in selecting a form of gate are: (1) design, (2) strength and durability, (3) weight, (4) construction, (5) material, and (6) cost. The strongest wooden gate is that made of oak, sawn or cleft, but the weight, which may range from 120 to 130 lb., necessitates a correspondingly strong setting. A gate made of larch or pine will weigh about 105 lb., yet if the swinging be perfect the life of it may endure as long as oak. The width of gateway for agricultural purposes should be 10 ft. in the clear, as this allows space for drills and all other implements, as well as for steam tackle. The gates, *therefore, should be 10 ft. 6 in. if so hung as to* close upon the side of the post. If hung upon the inner face, so as to swing both ways, they are the more likely to be left open. The design and construction are of importance; but as these

essentials may be obtained in many ways, they are open to variations. The essential point is that the strut should be notched into the heel and extend almost to the middle of the gate. This is the chief source of strength. There should be a top bar, forming part of the frame structure, and four minor bars, and if 10 ft. long there should be at least two vertical pieces. Another method is that of two struts upon each side; the one from the heel to the middle of the top bar, the other from the bottom of the head, meeting it, this being reversed upon the opposite side.

It is not necessary to dwell upon the many designs adopted in districts, for they are each and all based upon the leading principles of strength and weight. If they are of customary design and the essentials are met, it is not necessary to introduce another sort. To decrease weight without a corresponding decrease of strength should be the point aimed at, for a light gate well swung will last longer than a heavy and clumsy one, which, if out of order, will soon knock itself to pieces. A gentle swing may be further secured by all the essential pieces being made to taper towards the head. Immediately there is an indication of dragging, which denotes a lean of the hanging post, means should be taken to rectify it. This risk may also be minimized by reducing the length of the headpiece.

The cost of wooden farm gates varies in accordance with design, substance, and material. If of oak the cost of the gate alone will range from 16*s.* to 18*s.* If of red deal or larch, from 10*s.* to 12*s.* Cheaper gates can be purchased from wholesale makers, but it will be a doubtful policy to follow. The total cost, including posts, gate and fittings, and labour, will vary from 35*s.* to 50*s.* It is not an uncommon practice when valuing for dilapidations to assess the cost at 30*s.*, but this is quite insufficient if the result is to be worthy of the purpose. In detail the cost in oak will be as follows:—

	£	s.	d.
Oak hanging post, wrought, 10 in. by 10 in. by 7 ft. 6 in.	0	18	0
Oak striking post, wrought, 8 in. by 8 in. by 7 ft.	0	10	6
Gate of five bars, including top piece	0	15	0
Fittings	0	5	0
Labour	0	3	6
Total cost	2	12	0

The above represents the best oak field gate, but with smaller scantlings, and posts and gate of red deal or larch, the cost should not exceed 35*s.* It is a wise plan, if the dividing fence be a live hedge, to set up at least one panel of post and rail fencing on each side, as this prevents the brushing of hay and straw when passing through. The illustrations (see figs. 26 and 27) are examples of typical gates suitable for agricultural purposes. The first is for communication between fields, the second for roadside boundaries.

Iron Gates.—Iron gates are lasting if attended to; but they are more liable to injury and derangement, and are more inclined to drag at the head than wooden gates. This is due to their weight, and lack of elasticity or rebounding properties. They are dead and unresponsive if not perfectly hung. These defects may be overcome by carefully carrying out the guiding principles. The chief step towards securing these lies in the strength and setting of the hanging posts. These may be of iron, made specially for the purpose; of stone in stone districts, or of oak. The last, if 10 in. by 10 in., is, we think, the best of all.

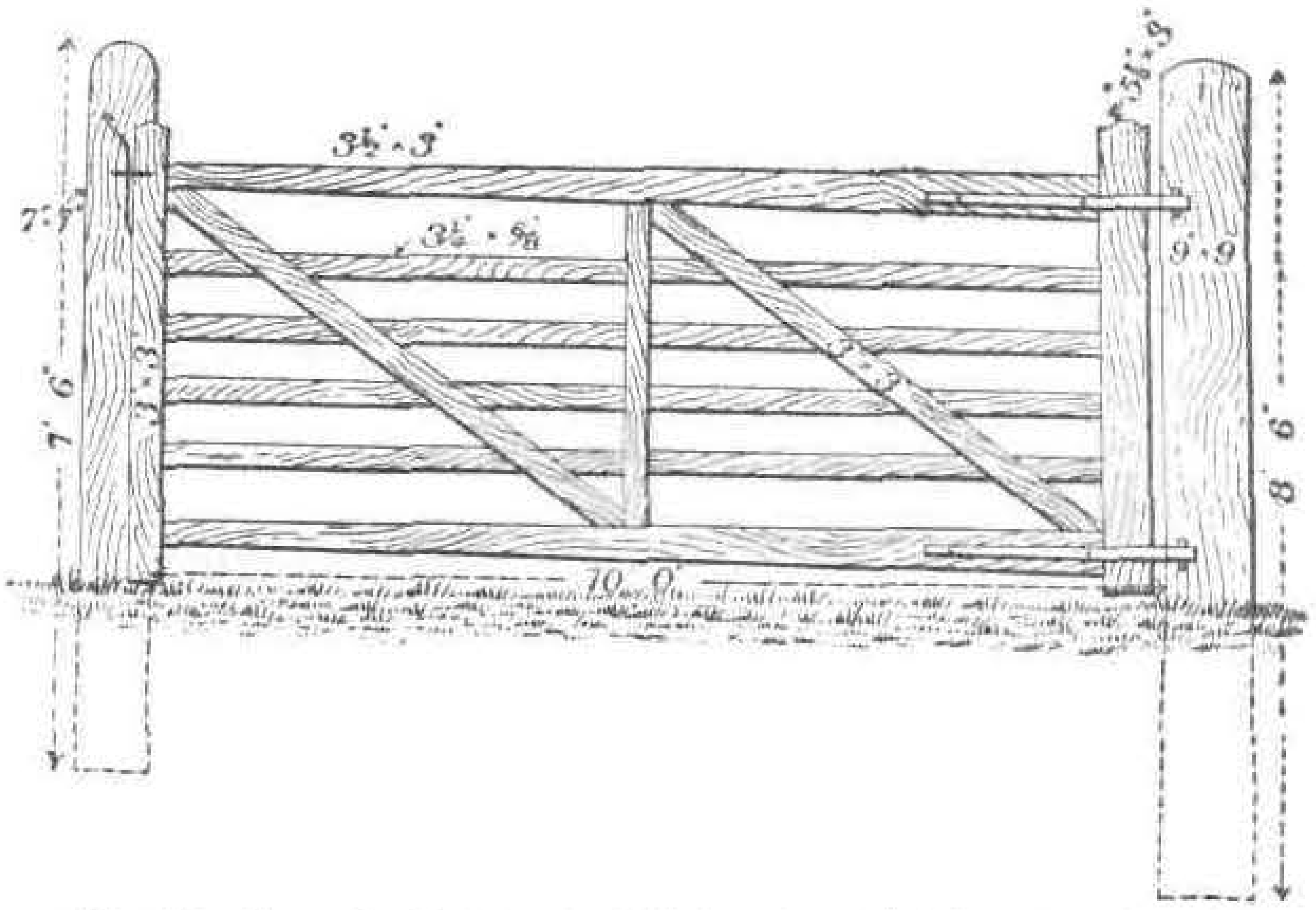


Fig. 27.—Example of strong Field Gate suitable for Fences on the side of a Highroad

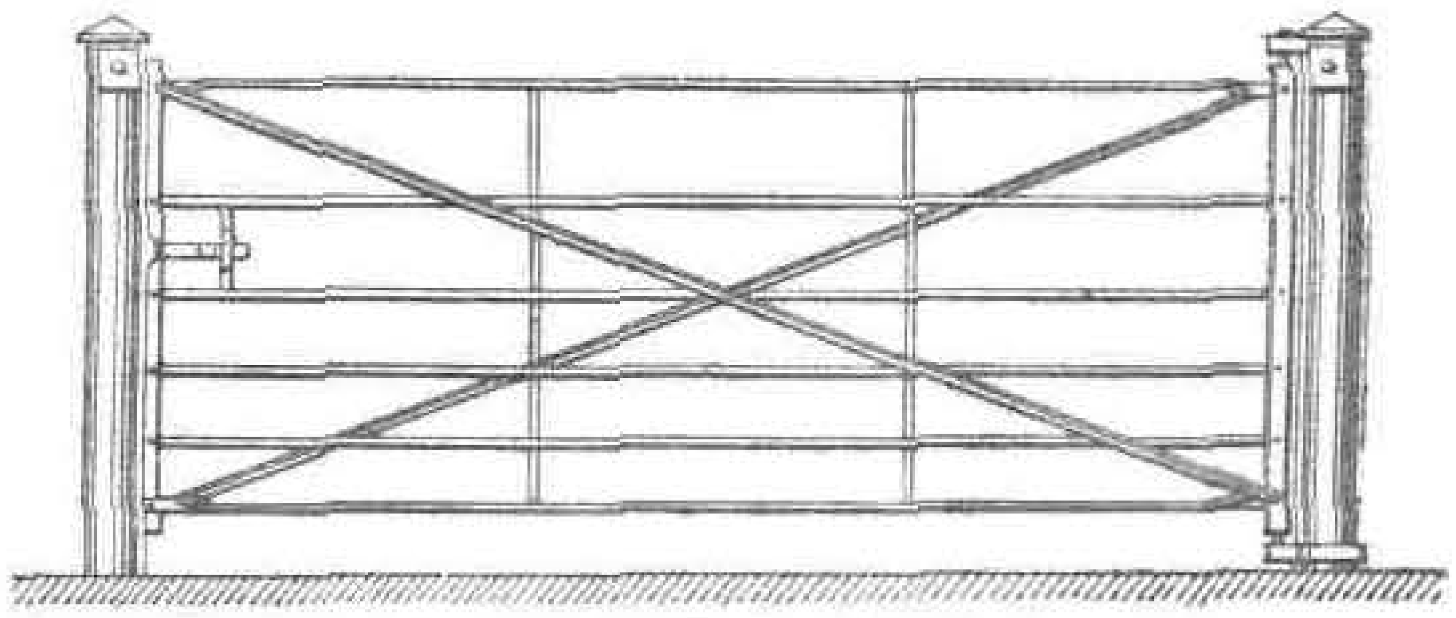


Fig. 28.—Simple Iron Field Gate

Elaborate iron gates and posts are better fitted for parks and demesne grounds than for simple agricultural purposes. Gates, simple in structure and not too heavy, hung upon oak posts will be found useful for field purposes, especially in districts where timber is scarce. They are, of course, in keeping with all kinds of iron fencing, and by the use of modern appliances will be perhaps preferable to wood. The cost of iron field gates, simple in design, will range from 21*s.* to 30*s.* each, and the accompanying illustrations show two of those most suitable.

Hanging of Gates.—The methods of hanging gates are numerous, and should be selected ac-

cording to the purpose and local conditions. If the gate be required to fall back upon the fence, as all farm gates should, the placing of the hooks will differ from that of a gate which opens only to a right angle. The position of the hooks, too, will govern the closing; such points, small in *themselves, become important to secure that* true adjustment so essential to the life of a gate.

If the gate be hung upon the horizontal face of the post, the hooks should be so arranged as to give a momentum sufficient to effect the closing without undue force. This may be effected by setting the top hook 36 to 42 in. vertically from the bottom hook, and 1 in. to 1¼ in. nearer the head, and by a projection of ¾ in. of the bottom hook from that of the top. These measurements may be modified to obtain the momentum required. If a gate be required to keep in position at any point of its swing, and not to be self-closing, the top and bottom hooks should be set in the same vertical and horizontal plane. It will add to the life of a gate, and

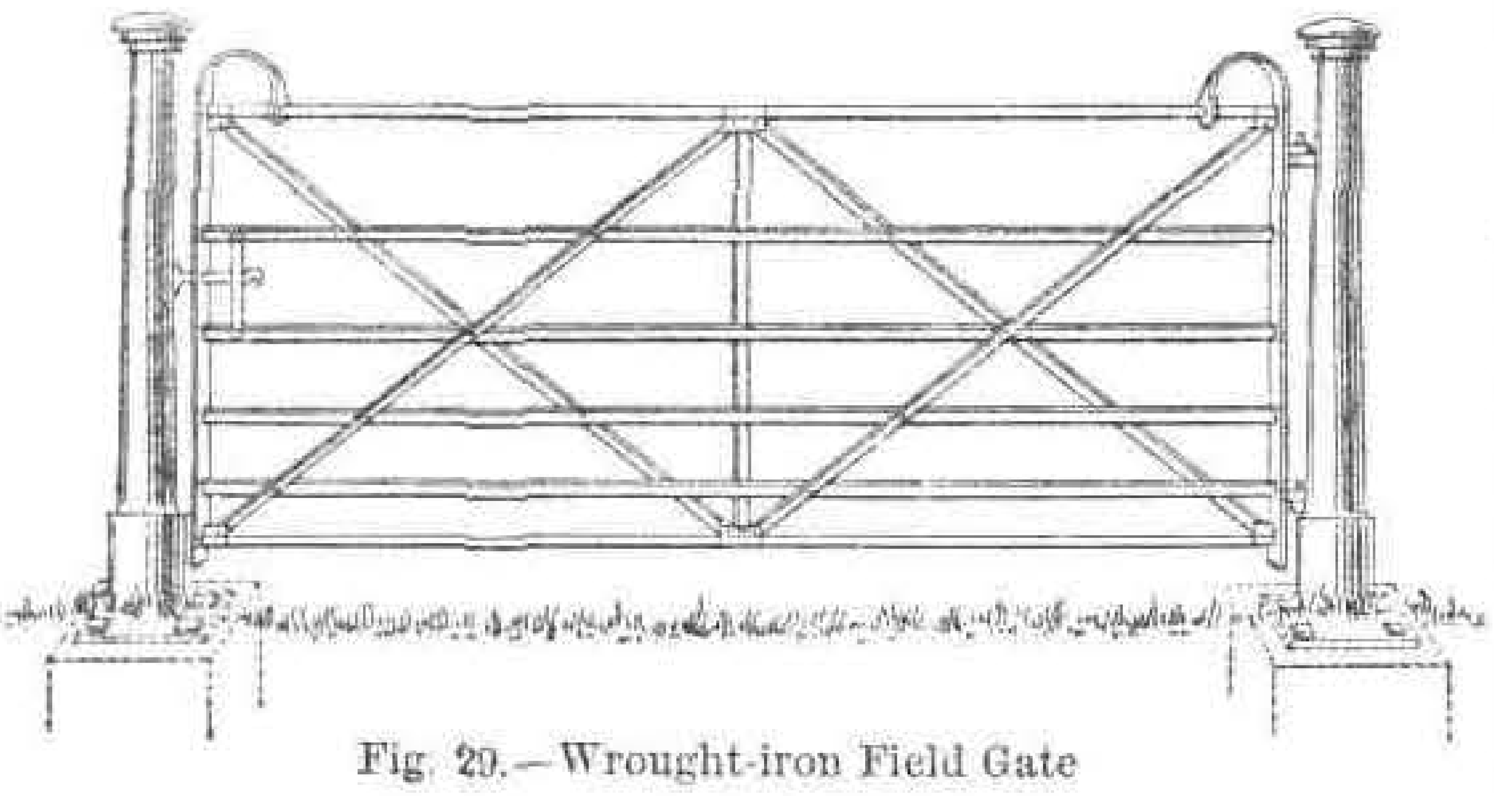


Fig. 29.—Wrought-iron Field Gate

effect a saving in the cost of the hanging post, if the heel crook be allowed to work in a socket, which may be of oak, stone, or iron. This will take the weight of the gate off the post. It is important that the hooks, hinges, and other iron fittings should be strong and secure in their attachments, and the weight of such should accord with the substance of the gate.

The points to consider in arriving at a conclusion in respect of closing are: (1) a self-closing gate if imperfect will be often insecurely fastened, due to which trespass of cattle may ensue; (2) if allowed to fall back with a jar, the life of the gate will be shortened; (3) if a non-closing gate, an effort will be made by the person passing through; and (4) if allowed to fall back in a line with the fence, it will escape injury by the passing of carts and farm implements. We think the points are in favour of a non-closing gate.

Rabbit Fencing

The subject of farm fences will be incomplete without considering the protection of crops from rabbits and hares. The loss by ground game is so manifest upon many farms, that if some protection were not afforded profitable farming would become impossible. Upon farms bordering on woodlands and wastes there must be a constant passage of rabbits, and this can only be prevented or abated by wire netting. If money be spent in the purchase of netting and if it be carelessly erected, it will be a manifest waste. Too often small coppice stakes are set up, and the netting strained from one to the other, with the result that rabbits burrow under or jump over. In time the netting bends over, becomes crumpled, and finally ceases to *perform its function entirely.* There are two kinds of protective fencing—(1) that which is to stand permanently, and (2) that which is for a season's protection to a corn or other crop. The first becomes necessary in the case of a plantation, or where the farm borders upon woodland or waste, and where the farmer cannot protect himself even by the full exercise of his right to kill; the second where corn is sown over which rabbits have access. If a fence exists, such as a wire or post and rail, netting may be attached at a moderate expense; but where such does not exist, an independent fence must be erected. The following points are essential to secure efficiency: (1) a sufficient height, (2) a sufficient gauge, (3) a correct mesh, (4) stability, secured by a top wire, and (5) the sinking of a portion of the netting beneath the soil.

Taking these points separately, (1) 3 ft. may be taken as the minimum, and 3 ft. 6 in. as the maximum height. If less than 3 ft., rabbits may jump over, and even 3 ft. will be too low if the ground slope or is uneven and irregular. 3 feet 6 in. will render it secure. (2) The gauge should be No. 17 or No. 18; if lighter, rabbits will cut the wire and pass through. (3) The mesh should be 1¼ in.; if 1½ in., small rabbits will pass through. (4) A top wire is essential to stability. This, which may be a No. 6 or No. 7 gauge, strained on the top to the height of the netting, the netting being laced to it, will render the whole firm and permanent. (5) The netting should be 6 in. in width greater than the height of fence, as this will allow of 6 in. being buried horizontally beneath the soil. The trench to receive it may be dug by hand or ploughed. The first is best, though the cost will be more. The horizontal bend should extend upon the outside of the fence. The straining posts may be 6 in. by 6 in., or 7 in. by 7 in. may be better. For intermediate stumps of oak, if sawn, 3 in. by 3 in. will be a useful size, or larch poles may be used if preferred.

The following precise figures may be found useful. Height above ground 3 ft., stumps 4 ft. 6 in. in length, 3 in. by 3 in. scantling, and 9 ft. apart.

	£	s.	d.
2 light straining posts, 7 in. by 7 in. by 5 ft., at 4s. 6d.	0	9	0
2 stays at 6d.	0	1	0
100 stumps, 4½ ft. by 3 in. by 3 in., at 4d.	1	13	4
¾ cwt. No. 7 galvanized wire at 10s. 6d.	0	8	0
6 rolls galvanized netting, 42 in. by 1¼ in. mesh, and No. 18 gauge, at 12s.	3	12	0
12 lb. lacing wire at 22s. per cwt.	0	2	6
Staples	0	0	3
Cartage	0	6	0
Labour at 1d. per yd.	1	5	0
Cost for 54 statute rods ...	7	17	1

or, 7d. per yard, about.

The above figures are taken from actual work performed.

The life of such a fence, if kept in repair, will be a long one. To prevent damage to the fence, and thus rendering it ineffective, stiles in suitable places should be erected. Rabbits which may be enclosed may be driven out by the erection here and there of turf ladders, which will enable a rabbit to get out but not return. Where a protective fence of this description is required for temporary purposes only, the cost will be naturally much less. Coppice stakes may be driven in 6 ft. apart to the height required, the netting buried to 6 in., and tied to the stakes with tarred string. The cost will probably not exceed 3*d.* per yd., and the netting, if rolled up carefully when out of use, will last for many years.

Concluding Remarks

The class of fence, the laying-off of fences, and the possibility of their reduction must be governed by the kind of soil, class of husbandry, and natural features. If the farm be purely arable the line of fences may be governed by area of fields best adapted to the cropping, and by roads, watercourses, drainage, and buildings. If the farm be pasture the water supply will largely determine the position of fences; also the aspect, for the hedges should protect from searching winds and not exclude the sun. Area of fields will be governed by the size of the farm and the course of its husbandry; but it will be better, especially in grass land, to have a superabundant supply of enclosures rather than an insufficient supply, for it doubtless tends to efficiency. Upon sheep-farms, especially if bordering upon downland, large fields will be as convenient as small, and in such a case many existing fences may be removed, straightened, or otherwise re-formed.

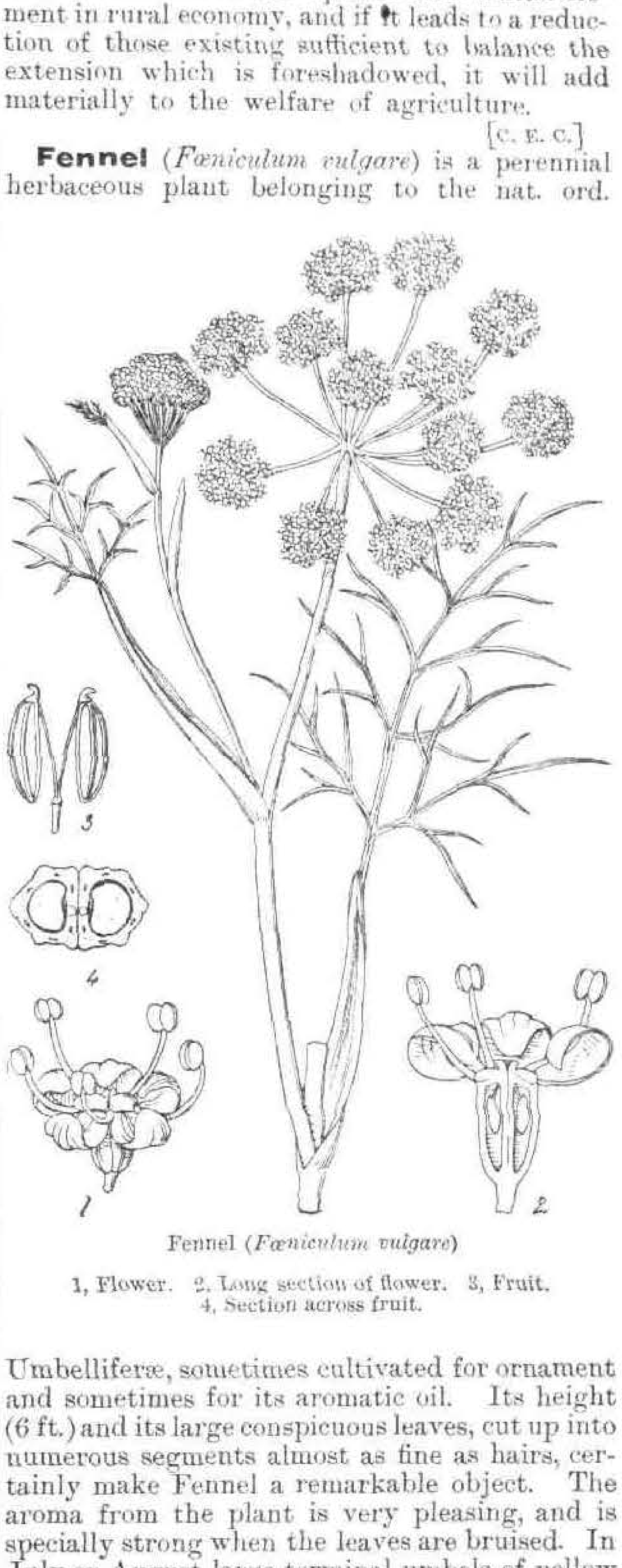
There can be no doubt that much of the irregularity of form of fields could be improved and rectified by a small expenditure; and by executing this there would follow—an increase of cultivable area, a saving in horse labour, a saving in dilapidation and consequent repair, and a saving in the tending of live stock.

Upon mountain, hill, and down farms shelter can be best afforded by well-arranged plantations or wide belts. If these exist, or can be supplied, the character of fences will be of less importance; but, nevertheless, under these conditions they should be efficient both for shelter and safe enclosure.

The great lessons to be learnt from the subject of fences are, that a sufficiency is wise, a superabundance of wide, encroaching fences is wasteful. Further, that if the country be taken generally—not in districts, because the variation of requirement is so great — a rearrangement of fences would add perhaps a million acres of cultivable land to the area now existing. The smaller the farms the greater will be the necessity for an extension of fences, because it is impossible to farm profitably open and unfenced areas. This means that a still further expenditure of capital will be required in the equipment of agricultural land, and a consequent reduction in the net rentals. The study of fences should be looked upon as an essential element in rural economy, and if it leads to a reduction of those existing sufficient to balance the extension which is foreshadowed, it will add materially to the welfare of agriculture.

[C. E. C.]

Fennel (*Fœniculum vulgare*) is a perennial herbaceous plant belonging to the nat. ord.



Fennel (*Fœniculum vulgare*)

1, Flower. 2, Long section of flower. 3, Fruit. 4, Section across fruit.

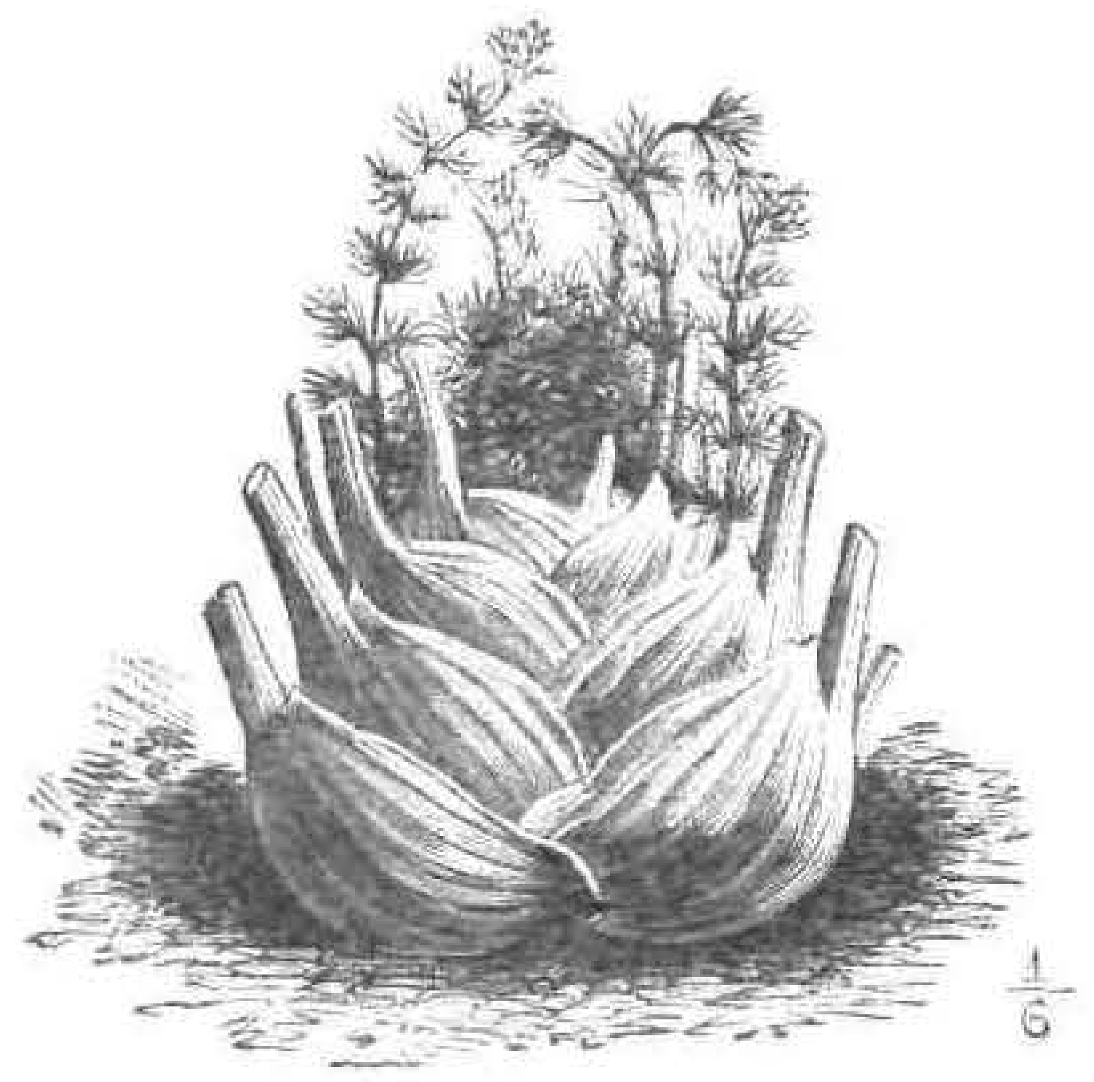
Umbelliferæ, sometimes cultivated for ornament and sometimes for its aromatic oil. Its height (6 ft.) and its large conspicuous leaves, cut up into numerous segments almost as fine as hairs, certainly make Fennel a remarkable object. The aroma from the plant is very pleasing, and is specially strong when the leaves are bruised. In July or August large terminal umbels of yellow flowers appear, and later on the fruits begin to ripen. The ripe fruit (called seed) is the part used for making fennel water (see also DILL), while the young shoots are sometimes used as potherbs and for garnishing.

The plant is grown from seed (really fruit), and the soils most suitable are sandy loams.

[A. N. M'A.]

A form of this plant is known as Finochio Fennel. This variety requires the same treatment as celery; that is to say, it should be planted in trenches and earthed up to induce

blanching. The form grown in England, known as the Sweet Fennel, is raised from seeds sown in spring on a light, warm soil in rows 15 in. apart, the seedlings being thinned to 1 ft. apart; or they may be raised in a bed and transplanted when about 3 in. high. As the plant is a perennial, a plantation will last several years. It is, however, advisable to top the plants in the spring to prevent their running to seed, and to induce the development of young and tender leaves, which are used for flavouring. The seeds are also used in the manufacture of liqueurs, as



Finochio Fennel

they contain an oil with a peculiarly aromatic odour. [W. W.]

Fennel, Hog's, a plant of the nat. ord. Umbelliferæ. See HOG'S FENNEL.

Fenugreek (*Trigonella fœnum græcum*) is a leguminous plant found growing native on the shores of the Mediterranean. It is an annual, and is cultivated for its value as a medicinal and forage plant. It grows to a height of between 8 and 10 in.; its yield, however, is small, and as it is not relished much by cattle, it is not important as a forage crop. Its seeds, however, have a characteristic aromatic odour and have a stimulating effect. They are used largely as a spice in special cattle foods, also as veterinary medicine. It grows best in moist climates and in soils well supplied with chalk. [R. A. B.]

Fermented Milk. — The term here employed is applicable to various developments, some of which are indigenous to certain countries in which the use of them has been maintained for a long time. There does not appear to be any one of these that can claim the right to the term 'fermented', in any sense as a monopoly. Any or all of them may use it, and no one may claim a patent right in it.

All kinds of cheese are made from milk, in the coagulation of which—whether natural or artificial—fermentation is employed. The rennet ferment is employed artificially; the lactic acid ferment should always be present in a predominant degree, whether the method of its application be natural or artificial. Other ferments, some of them useful, but most of them undesirable, and all of them interlopers, find their way only too frequently into milk, much to its detriment. And it follows that milk, a fluid most susceptible to ferments, can readily be fermented in any artificial way that may be desired; failing which it soon ferments in a natural way, that is to say, by ferments derived from the air.

There are, however, in various countries, ways of fermenting milk which may be admitted to possess some degree of speciality, inasmuch as the fermented mass is used for quick consumption as soured—or thickened—milk. 'Soor dook', which is merely buttermilk or skim milk naturally or artificially soured, has long been a popular beverage in some portions of Scotland. It must be admitted, indeed, that the custom is a wise one, because the lactic ferment gives to buttermilk or skim milk a medicinal value of some importance. Sour buttermilk, indeed, has been long regarded as a tonic whose value is underestimated by the majority of people. Probably it is not underestimated so much as not estimated at all—not known, in fact. The same may be said of whey, though it is not equal to buttermilk.

It is undeniable that thickened milk, if fermented with the lactic acid bacillus, is in all probability a much more valuable thing as a prophylactic than is generally realized. It is not used in England, save sporadically and to a small extent; but it is esteemed in southern countries, — Italy and Greece, for example — where it is probably more useful than it would be in a northern country. But in Russia fermented milk, prepared from mares' milk, and named koumiss, is held in high esteem as a 'pick-me-up' by persons of naturally weak constitutions, or who have been 'run down' by illness or hardships. Its value has been understood for a long period amongst nomadic tribes in northern Europe and Asia, in the Russian empire. Fermentation, however, is carried to an extreme degree, in strong bottles, until in about three days' time the liquid is decidedly alcoholic, and is then ready for use. See also art. KOUMISS. [J. P. S.]

Ferments and Fermentation. — The bodies called ferments have been known from a very early date; their nature and action, however, were not fully understood until within quite recent times. Although considerable knowledge has been gained during the last century of the properties, occurrence, and changes produced by ferments, a great deal still remains to be explained. The earliest examples recorded in ancient history of ferment action are the production of wine from grape juice, and the raising of dough in breadmaking. Owing, however, to the obscurity surrounding the nature of the changes involved in the above cases, little explanation of the observed phenomena could be given. It was seen that gases were evolved, that spirit was produced from grape juice, and that in the making of bread the disengagement of the gases caused the dough to swell. Both changes were connected with the presence of leaven. It was observed also, in the fermentation of grape juice, that a scum was formed, either floating on the top or as a sediment in the liquid, and it was known that small quantities of this scum were capable of producing

fermentation in fresh grape juice, just as small quantities of leaven were found necessary in breadmaking. The early observers applied the term 'ferment' to substances like leaven, which had the power of disengaging gas when in contact with certain bodies, and the term 'fermentation' was applied to the phenomena of ferment action, ferment being derived from the Latin *fervere*, to boil.

It was not until centuries later that the true nature of leaven was known. By microscopic examination it was then discovered to be a unicellular plant, namely the yeast plant. Many changes in which gases were evolved were at first wrongly attributed to ferment action, such as the action of acids upon chalk. The evolution of gases in the animal intestine was, however, rightly attributed to ferments, though their nature at the time was unknown. In the early part of the 19th century an action somewhat analogous to that of yeast was discovered to be in progress in germinating barley, and to be due to a substance which could be obtained as a whitish precipitate on adding absolute alcohol to 'steep' water obtained from germinated barley. This substance had the power of converting starch into sugar, gases were evolved, and the action appeared to be of a fermentative character. The substance was called a ferment and named diastase. Many similar changes were soon found to be in operation in the digestive juices, in seeds, &c., and it soon became evident that ferments such as diastase played a very essential part in the life of the organisms in which they occur. Fermentation now covers a wide range of actions, and ferments include a variety of bodies.

Ferment action is perhaps best illustrated in the decomposition and decay that vegetable and animal matter undergo when exposed to air. The changes proceeding in such material arise mainly through the action of ferments introduced from the atmosphere. Many of the compounds comprising animal and vegetable matter are readily fermentable, the rate of their fermentation is regulated by the conditions under which the action is proceeding. Each kind of ferment acts best under certain conditions; it follows, therefore, that the decay of organic matter is either slow or rapid according to the suitability or otherwise of the conditions under which the ferment is acting. The presence of moisture and warmth are essential to most ferment actions, whilst a temperature of 100° C. or 0° C., entire absence of water, and the presence of some organic or inorganic substances called antiseptics, entirely prevent the action of such ferments. This class of easily preventable ferment action is caused by living organisms called bacteria. Each bacterium is characterized by its shape, the particular food upon which it feeds, and the waste products resulting from its action. Micro-organisms producing fermentation are termed for convenience *organized ferments*. They are living organisms, capable of independent growth and of reproduction. For their growth they require a complete plant food, namely one containing nitrogen compounds, mineral matter, oxygen, and some fermentable carbon compound. The ferment action caused by them is the result of their own growth and development. In the case of most micro-organisms, the products of fermentation, if allowed to concentrate, are inimical to the further growth of the organism.

Those organisms requiring the presence of oxygen for their development are called aerobic, and those which thrive in absence of oxygen are called anaerobic. The actions of the latter class of organism are largely, though not necessarily, confined to changes in nitrogenous bodies, and generally result in the production of foul-smelling gases and of poisonous substances called ptomaines. The term 'putrefaction' is applied to such actions. Both kinds of these ferments operate in the decomposition of farmyard manure. Fungi and moulds are also included in the organized ferments. Protoplasm, whether in the form of naked amœboid masses or as an active constituent in living cells, possesses fermentative properties, and it plays a much more vital part in the changes arising from organized ferments than is the case with another class of ferment which will be dealt with shortly. Pure cultures of bacteria can be obtained by growing them in suitable culture mediums; for actual details of the methods of preparation and isolation, the reader must consult arts. on CULTURE, BACTERIAL, and BACTERIOLOGY.

Many fermentable bodies can be preserved for indefinite periods if the conditions are made unsuitable for bacterial growth. Thus milk readily turns sour in warm weather through bacterial action; if, however, the organisms causing this, and which are introduced into the milk from the atmosphere, are destroyed (1) either by boiling the milk and corking it up whilst boiling, or (2) by adding some antiseptic body to it, the milk will remain unchanged.

The changes caused by the organized ferments may be classed under the following heads:—

1. Fermentation by hydration.
2. Fermentation by decomposition.
3. Fermentation by reduction.
4. Fermentation by oxidation.

Examples of No. 1 are: the conversion of urea into ammonium carbonate — thus, $CO(NH_2)_2 + 2H_2O = CO(ONH_4)_2$; of hippuric acid into benzoic acid and glycocoll.

Example of No. 2 is the formation of lactic acid from the sugar lactose.

Ferments included in No. 3 may be further subdivided into (*a*) those reducing alcohol—example, the conversion of glycerine into butyric acid. Several ferments of this class are found in hay infusion, they convert erythrite into succinic, butyric acid, &c., and the substance quercite into butyric acid also; (*b*) fermentation by reduction of carbohydrates. The sugars glucose, lactose, and saccharose readily undergo fermentation by micro-organisms and yeast. The action of yeast upon glucose has already been mentioned, the chemical changes accompanying the action are as follows: $C_6H_{12}O_6 = 2C_2H_6O + 2CO_2$. In addition to ethyl alcohol, other higher alcohols and acids are formed in small quantities. This ferment action constitutes at the present time practically the only commercial source of

ethyl alcohol. It is the well-known vinous fermentation of grape juice, and forms the basis of the manufacture of wines, liquors, liqueur, beer, &c. The manufacture of *koumiss* from mares' milk is a ferment action in which yeast plays an important part. Mares' milk contains the sugar lactose, and this is acted upon by several ferments, producing alcohol, lactic acid, and carbon dioxide. The product koumiss is used as a beverage in Russia. *Kephir* is a beverage made in the Caucasus by the action of yeast and other ferments upon cows' milk. In this case alcohol and lactic acid are formed. Both the above beverages are effervescent.

Koji is a Chinese beverage made from steamed rice. Alcohol is produced, but the ferment in this case is a fungus and not the yeast plant. *Arrack* is a beverage made in Java, and it is prepared from rice starch by the action of a fungus and some micro-organisms. The souring of milk is caused by a ferment which converts milk sugar into lactic acid. The butyric fermentation usually follows this change. It is an anaerobic ferment, and produces carbon dioxide and hydrogen along with butyric acid. Starch, dextrin, and inulin are also acted upon under suitable conditions by the butyric ferment. Cellulose during digestion is acted upon by ferments, producing marsh gas and hydrogen. A large number of the salts of fatty acids undergo fermentation by micro-organisms, forming acids of lower molecular weight. The reduction of nitric acid to free nitrogen by the denitrifying ferment and of sulphates to sulphuretted hydrogen are other examples.

Among the fourth class of fermentations, the acetic acid and the nitrifying ferments are among the most important.

The type of fermentation so far discussed have all been produced by the direct action of living organisms. As previously mentioned, another class of fermentation exists, in which the presence of living protoplasm is not essential for the activity of the ferment. The action of diastase upon starch was given as an example. This class of ferment exists in the cells of plants and animals, and can be extracted from them by water or glycerine without decreasing their fermentative powers. They possess no organized structure, are incapable of reproduction, and dilute solutions of antiseptics do not destroy them. They are called *unorganized ferments*, *enzymes*, or *soluble ferments*. The main difference between the organized and unorganized ferments is shown in the following table:—

	Unorganized ferments.	Organized ferments.
Temperature:— In solution, 65° C. to 80° C.	Destroyed.	Destroyed, except some with spores.
In a dry state, 100° C. to 160° C.	Many unchanged.	All killed in a few hours.
Alcohol	Precipitated, still active.	Killed.
Antiseptics ...	Unaltered if solution be dilute.	Killed.

Enzymes exist in, and have been extracted from many of the organized ferments, and there is no really fundamental difference between the two classes of ferments. The influence of protoplasm is more active in the case of the organized ferments.

Enzymes have never been prepared artificially; they are always obtained from plant and animal organs by adding alcohol, which precipitates them out from a solution in water or glycerine. Temperature directly affects their activity in producing chemical change. The organ in which enzymes occur is called the zymogen; thus the pancreas is the zymogen of pancreatic juice. Each enzyme has a zymogen; occasionally the zymogen produces no enzyme until it is warmed for a few hours with dilute acid, when it is secreted. Enzymes are very complex bodies. They contain nitrogen, and one of their principal characteristics is that a small quantity of the enzyme is capable of producing a chemical change in a large quantity of substance. The mode of action of enzymes is not well understood. The chemical change is generally one of hydration, and appears to resemble the action of sulphuric acid upon starch. It is at any rate a catabolic change, and results in the production of less complex from more complex bodies. The medium in which the enzyme is working has a direct influence upon its activity, thus some enzymes require acid and other alkaline mediums.

For convenience the enzymes have been classified according to the material upon which they work as follows:—

1. Those which transform insoluble carbohydrates into sugars. They include diastase, which converts starch into sugar; inulase, which decomposes inulin; and cytase, which decomposes cellulose.

2. Those which transform biose sugars into hexose sugars. Invertase is an example.

3. Those which decompose glucosides include emulsin and myrosin.

4. Those which decompose proteids into peptones and amino acids include pepsin and trypsin.

5. The clotting enzymes—they include rennet, thombase, and pectase.

6. Those which decompose oil and fats include lipase.

7. Those causing oxidation in organic substances—examples, laccase and tyrosinase.

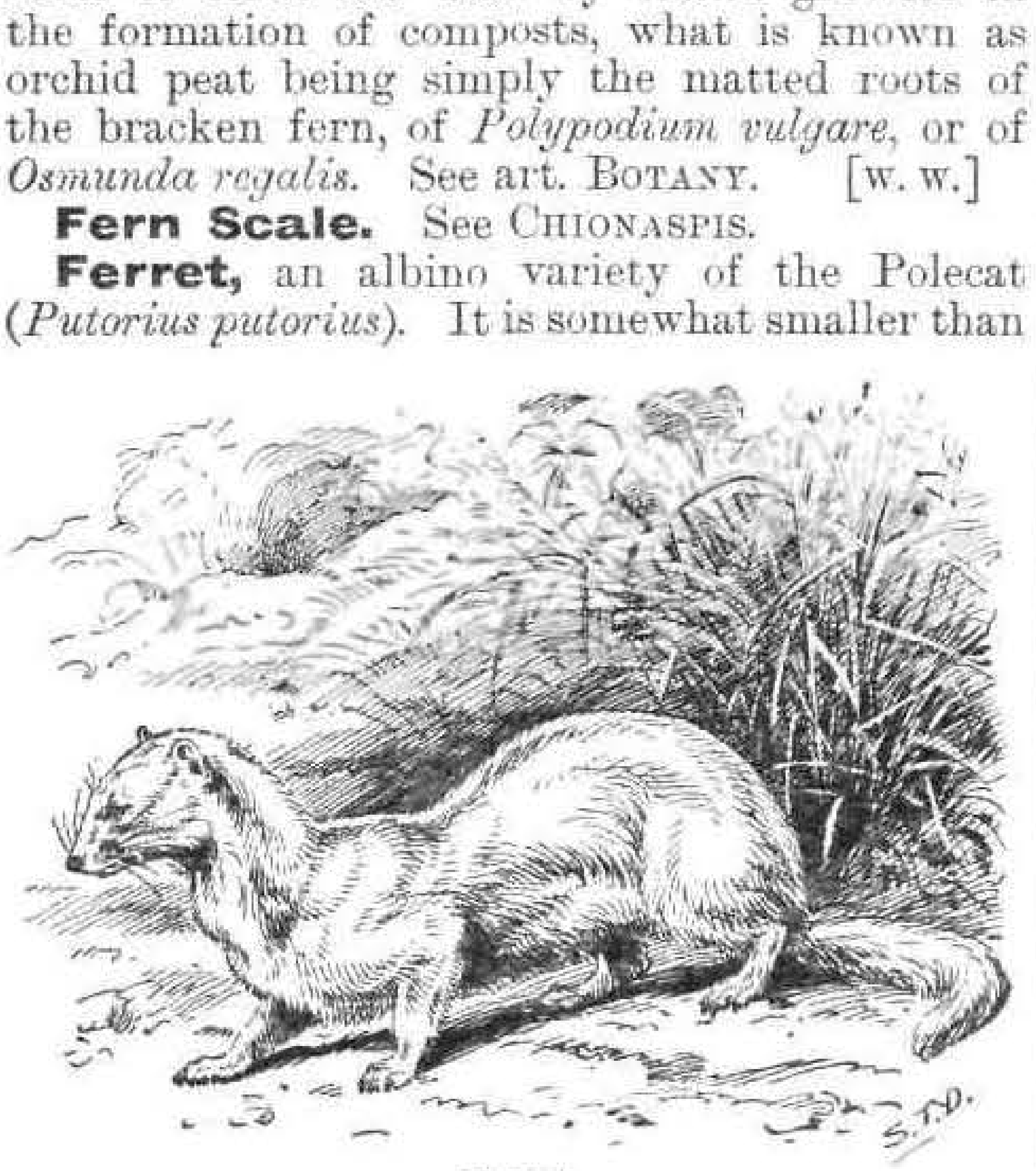
From the above sketch of ferments and their action it will be clear that they take a very essential part in many industries, in agriculture, and in most natural processes. [R. A. B.]

Fern.—Ferns constitute a large and important section of the vegetable kingdom. They are distinguished from flowering plants by their mode of growth and their method of reproduction, which is by means of spores borne in capsules on the back or margin of the leaf (frond); the spore vegetates and produces a cellular expansion (prothallus), on the lower surface of which are developed little bodies of two sexes, the male (antheridia) being microscopic coiled threads which under the influence of moisture move actively until they come in contact with a female cell (archegonia), which they enter, fer-

tilize, and thus give rise to a new plant. The stems of ferns form either a rosette or a creeping rhizome, or they may develop into what are known as Tree Ferns. Ferns are found all over the world where vegetation of any kind can exist, moist tropical conditions being most favourable to their full development. In New Zealand, Tree Ferns form an important feature, covering large areas, especially in the valleys. In the British Islands they grow generally in moist shaded places, although many of them are quite happy when exposed to full sunshine, as is proved by their behaviour under cultivation. Ferns have become popular garden plants, and collections of tropical, subtropical, temperate, and hardy kinds are not uncommon in European gardens. At Kew the collection of ferns numbers over 2000 species. Generally they are very easy to cultivate. They like a sweet, well-drained soil and plenty of moisture. Some of the species are cultivated in large quantities by market growers for the decoration of rooms, &c. The roots of ferns are used by orchid growers in the formation of composts, what is known as orchid peat being simply the matted roots of the bracken fern, of *Polypodium vulgare*, or of *Osmunda regalis*. See art. BOTANY. [W. W.]

Fern Scale. See CHIONASPIS.

Ferret, an albino variety of the Polecat (*Putorius putorius*). It is somewhat smaller than



Ferret

the polecat, being usually about 14 in. in length including the tail; it has creamy-white or yellowish fur, and red eyes. A good ferret for working and breeding purposes should have 'the body slim, lengthy, and muscular, legs and feet sound and strong, its face sharp, fur clean, glossy, and thick, and it should be quick in movement'. The ferret breeds true, but it can be readily crossed with the polecat, and the hybrids are more active and fiercer than the pure-bred animal; they are also hardier, but are so shy and wild that they are very difficult to handle. A polecat, taken young, may also be used just as a ferret is used.

The ferret is of southern origin, and cannot stand the cold of an English winter without protection of some sort. It is a delicate animal in many ways, and requires great care and attention. Absolute cleanliness and dryness of the hutch is essential, for in a damp, dirty box it is extremely liable to distemper, foot rot, and other troubles, and it quickly gets out of condition through the constant irritation caused by ticks and other parasites.

Two litters are produced in a year, each numbering six to nine young ones. The gestation lasts about two months. The hutch must be carefully cleaned some days before the young are born, and then left quite untouched until they are two or three weeks old, for the mother is apt to destroy them if they are molested. The mother should have fresh meat once a day, as well as plenty of milk. When the young ferrets begin to show themselves they should be handled frequently, so that they may become accustomed to being caught. At three months old they may be taken with their mother to the warrens to learn their business.

Ferrets are employed chiefly for rabbit-hunting and ratting. For rabbit-hunting they are usually muzzled in some way, lest they make a full meal and 'lay up' within the burrow, when they are often difficult to recover. The wire muzzle is no longer much in vogue; various methods of 'coping' with fine whipcord are preferred by most gamekeepers. For ratting, only strong and experienced ferrets are used, and they are left unmuzzled. 'Polecat-ferrets', as the hybrids with the wild variety are called, are frequently preferred for rat-catching. Care must be taken to examine the ferret for rat-bites, and to wash these with carbolic oil or some other disinfectant dressing, or blood-poisoning may supervene.

The ferret has been known for many centuries, and the Romans used it very much as it is used now. But notwithstanding this long association with man, it cannot be regarded as a domesticated animal, for though it gets accustomed to the handling of its master it never becomes really tame, and it is always an unwilling captive. If it does escape from a carelessly fastened hutch it may do much damage among chickens, and a case, apparently well authenticated, is on record of a sleeping infant being attacked and badly wounded by an escaped ferret. See next art. [J. A. T.]

Ferreting.—To the farmer the ferret is a most useful little animal, though it is surprising how seldom it is kept by such, most of the work required from it being left to the rat-catcher, and to the gamekeeper or the warrener. There is no necessity to dwell upon the serious damage done by rodents (rats, rabbits, &c.), which may be greatly reduced if agriculturists would only be persuaded to take a little keener interest in the destruction of these pests, especially rats. There are generally boys about a farmsteading, and it does not, as a rule, require much persuasion to induce a youth to indulge in this form of sport as a pastime, more especially if a trifling sum be paid for every head of such vermin destroyed. The ferret belongs to the genus Mustela (one of the Carnivora), and has been derived from the polecat, formerly known as the fitchet weasel. There is the white ferret with pink eyes, and the brown ferret with intermediate crosses. Good working ferrets can be bought for 3*s.* 6*d.* each, and it is better to buy one that

has been worked without a line; but if there is plenty of work it is possible to keep a couple, one being a dog ferret, used to working on a line, so that if the other ferret, preferably a bitch, 'lays up', the line ferret can be sent in to drive her out. It is not a good plan to use the same ferret for ratting and rabbiting, as the former require to become more ferocious, which is objectionable in a ferret required for bolting rabbits. If a dog (hob) and bitch (jill) ferret are bought, they can be used for breeding purposes as well. In this manner one can supply himself with fresh stock, and sell off the surplus, say at 2*s.* each. Handle the young ferrets as soon as they leave the bitch, which is about the end of the fourth week, and in handling a ferret always grasp it firmly and unhesitatingly around the neck and shoulders, as some ferrets are inclined to be vicious, especially if timidly handled. Some gamekeepers muzzle their ferrets before putting into the burrows; others practise what is called 'coping', *i.e.* passing a piece of whipcord through the lips to close the mouth. If a ferret has been well handled, and comes from a good working strain, there is no necessity for either of these practices.

A bitch ferret carries her young for six weeks, the latter being hairless, blind, and deaf when born. Flesh and a little milk are the only foods needful, but both of these should be given fresh, as ferrets have a natural desire to sneak food into the place where they sleep, so that care should be taken to prevent this as much as possible. Feeding in the evening is the best plan, and only give a little milk in the morning when required for work. Clean hutches out twice a week at least in winter, and every other day in summer. A box with a sleeping apartment containing straw, and a small run, with ½-in. wire netting in front, makes a capital ferret hutch, especially if raised 3 or 4 ft. from the ground. A carrying box or bag is used to take the ferrets to the seat of operations, and a terrier or two plus a spade and net completes the outfit, unless bolting rabbits for shooting. If the terrier has been trained to its work, *i.e.* to be 'true to hole', the rat, &c., will be laid *hors de combat* directly it shows at the mouth of the hole. Digging out a ferret is often a tedious business, and a great deal of time may be lost in this manner; however, it is often unavoidable. Chirruping at the hole will frequently cause a ferret to reappear, so will fresh flesh, but as a rule a well-trained ferret does its work with tolerable regularity, reappearing when the burrow has been cleared.

[F. T. B.]

Ferruginous Soils. See Iron Compounds in Soil.

Fertility.—The subject will be dealt with under the following headings:—

I. Historical.

II. The conditions necessary for fertility.

III. The effect of the chemical composition and physical properties of the soil on its fertility.

IV. Indications of fertility and barrenness.

V. 'Inherent fertility' and 'condition'.

I. Historical. — Speculations on the causes of fertility in soils have been common in all ages, but it is only within recent years that they have been submitted to the rigorous experimental tests necessary to give them either scientific or practical value; we need not, therefore, concern ourselves with more than a few of the most important. Of all the earlier writings, few are more in line with modern views than those of Bernard Palissy, the French potter (1510–1589). In his Recepte Véritable (1563) he sets out a striking theory of manuring. 'You will admit that when you bring dung into the field it is to return to the soil something that has been taken away. . . . When a plant is burned it is reduced to a salty ash called 'alcaly' by apothecaries and philosophers. . . . Every sort of plant without exception contains some kind of salt. Have you not seen certain labourers, when sowing a field with wheat for the second year in succession, burn the unused wheat straw which had been taken from the field? In the ashes will be found the salt that the straw took out of the soil; if this is put back the soil is improved. Being burnt on the ground, it serves as manure because it returns to the soil those substances that had been taken away.'[1] A fertile soil was evidently regarded as one containing abundance of these salts.

Another remarkable view was put forward nearly a hundred years later by Glauber in his Deutschlandt's Wohlfahrt (1656). Having obtained saltpetre from the earth cleared out from cattle sheds, he argued that it must have come from the urine or droppings of the animals, and must therefore be contained in the animals' food, *i.e.* in plants. He also found that addition of saltpetre to the soil produced enormous increases in crop. He connected these two observations and supposed that saltpetre is the essential principle of vegetation. The fertility of a soil is entirely due to the saltpetre it contains, and the value of manure (he mentions dung, feathers, hair, horn, bones, cloth cuttings) depends solely on the saltpetre present.[2]

Other theories of plant nutrition and of fertility were also in vogue, and these two were by no means widely accepted. At a later period the celebrated Leyden professor Boerhaave (New Method of Chemistry, Eng. trans. 1727) taught that plants live on juices derived from the 'fatty' parts of the soil (*e.g.* clay), but 'fatty earth' alone is very sticky and unsuited to plants; it can only be made fertile by mixing with sand 'to keep the pores of the earth open, and the earth itself loose and incompact, and by that means give room for the juices to ascend, and for plants to be nourished thereby' (p. 124).

This idea was very considerably developed in Agriculturæ Fundamenta Chemica by Wallerius (Sweden, 1761), one of the first textbooks on agricultural chemistry. The constituents of the soil may contribute to its fertility either by

[1] En la cendre de ladite paille, sera troué le sel que la paille auoit attiré de la terre, lequel sel demeurant dans le champ, aidera derechef à la terre. Et ainsi la paille estant bruslée dedans le champ, elle seruira d'autant de fumier, parcequ'elle laissera la mesme substance qu'elle auoit attirée de la terre.

[2] Erstlich und vor allen muss dieses gelden und statt finden, dass alles dass jenige so die Felder dünget, einen Salpeter in sich haben müsse; dan alle fruchtbarkeit der Erden allein und einig von Ihme berühret, welches unwiedersprechlich'. (p. 111).

providing plant food or by their mechanical action. Plant food must be of the same nature as the plant itself, mineral matter is of no use; humus or mould being derived from plants, is alone effective. Clay has a valuable mechanical effect, however; it attracts water and 'fatness' from the air and holds the 'fatness' of manures, preventing it from being washed away by rain. Chalk also attracts 'fatness'; it warms the land, destroys acid, and dissolves the 'fatness' of the soil. Sand opens up clay and peat soils, rendering them more easy to work. A soil is fertile if it contains all these substances in amounts suitable and sufficient for plant growth. Salts such as saltpetre, wood ashes, common salt, &c., he considers to have no nutritive value: any effect they may produce is entirely indirect, and due to their aiding the solution of the 'fatness' of the soil.

It is always difficult to know exactly what an old writer means when he sketches out a hypothesis, and we must not make the mistake of reading too modern a meaning into the various views given above. Really definite theories, capable of being experimentally tested, were not possible till chemistry became a systematized science, and this did not happen till the end of the 18th and the beginning of the 19th centuries. At this point there is a great break in the history of the subject; henceforward theories of fertility could be clearly formulated, and deductions drawn from them could be submitted to the test of experiment. The first notable production in the new period is Davy's Lectures on Agricultural Chemistry (1812). The ideas are probably substantially the same as those of Wallerius, but they are now made definite and capable of experimental trial; a great advance has been made in method if not in subject-matter. 'Water and the decomposing animal and vegetable matter existing in the soil constitute the true nourishment of plants.' Salts may perhaps be of use, if so they are needed to supply 'that kind of matter to the vegetable fibre, which is analogous to the bony matter in animal structures'. The physical properties of soil are highly important, especially its power of absorbing water from the air and its relationship to heat; they depend on the relative proportions of organic matter, sand, clay, and chalk. The two latter have a chemical as well as a physical function; besides attracting moisture from the air and generally regulating the water supply, they also combine with vegetable and animal matters and so prevent them from being decomposed by the action of the atmosphere or washed away by rain. A fertile soil must contain all four constituents, organic matter, sand, clay, and chalk, in proper amounts, and to facilitate his investigations he designed methods of soil analysis for measuring the quantities present.[1] These methods still remain, in a modified form, in use to-day. See art. ANALYSIS.

For the next thirty years, fertility was supposed to be mainly a physical question. Schübler (Grundsätze der Agrikulturchemie) made a very full study of physical properties of the soil, and based his classification of soils on the results of mechanical analysis. Morton (Soils, 2nd ed. 1840) wrote: 'The productiveness of any soil depends entirely on its natural or artificial capacity of retaining or transmitting its moisture. . . . All mineral manures, as lime, chalk, marl, sand, gravel, ditch mould, road scrapings, and other earthy matter, act on the soil merely *as an alterative* by changing the constituents of the soil and improving its texture.' A number of facts were, however, being discovered which showed this view to be incomplete. Investigations on plant nutrition were being carried out. The fact that plants got their carbon from the air and not, or not entirely, from the soil was definitely established. Analyses of plant ash made by de Saussure, Boussingault, and others showed that potash, lime, phosphates, &c., were invariably present, while the sand cultures made by Wiegmann and Polstorf[1] proved that these constituents played an important part in the nutrition of the plant. Many fertile soils were examined, and found invariably to contain plant ash constituents. Ure[2] attributed the fertility of an East Lothian soil to the phosphates he found therein. Boussingault, at his farm at Bechelbronn, analysed the crops and the manures supplied, and so ascertained the changes suffered by the soil. All these facts, however, were more or less isolated, till Liebig connected them all in his brilliant theory of plant nutrition, published in 1840 as a report to the British Association. Plants require as foodstuffs the alkalis, silicates, phosphates, sulphates, and also carbonic acid, ammonia, air, and water. All of these must be supplied or full development is impossible; the first four, being mineral, come from the soil, and the supply can be ascertained by analysis; the rest come from the air and are present in unlimited quantities, but the amount reaching the roots—and this is an important factor—depends on the physical nature of the soil and on the operations of tillage. Chemical composition and physical properties are of equal importance; unless the physical conditions are right the soil will be sterile, no matter how satisfactory the chemical composition may be, and vice versa. Regulation of the physical conditions is the farmer's business, and belongs to the art of agriculture. Determination of the chemical composition is the business of the scientist; the mineral substances he finds to be deficient must be added as manure. Alkalis and silicates are for the most part present in very insoluble combinations, but they are dissolved by rain, air, and carbonic acid during weathering, and this process is hastened by cultivated fallows or by dressings of lime. The minerals required by a particular crop may be ascertained by analysis of its ashes. It is possible to arrange the rotation so that plants are not grown more frequently than their foodstuffs become by weathering 'fit for assimilation', and so to make the maximum use of the soil constituents, but the soil must ultimately become exhausted unless the proper mineral manures are added.

[1] Methods embodying the same principles had already been used by Lord Dundonald (A Treatise on the Connection of Agriculture with Chemistry, 1795).

[1] Quoted in Liebig, Agricultural Chemistry (Appendix).
[2] Dictionary of Chemistry, art. Soils.

A modification of this theory was necessary later on, when Lawes and Gilbert showed that plants must be furnished with nitrogenous manure. Rain supplies very little ammonia; plants cannot take in free nitrogen, and apparently can utilize very little of the nitrogen in the soil. When mineral manures only are applied, crops are little or no larger than on unmanured ground, but when nitrogen compounds are added to the mineral manures considerable crop increases are obtained.

It was soon found, however, that the analytical results did not always fall in line with the practical experience of the farmer. Soils declared by the analyst to contain ample quantities of all mineral food were nevertheless found to be unproductive, and to respond freely to dressings of mineral manures. The distinction already made by Liebig, and developed by Daubeny (Phil. Trans. 1845, p. 185; also Jour. Roy. Agric. Soc. 1846, vii, 237), between available foodstuff 'fit for assimilation' and non-available, was therefore emphasized, and called in to account for discrepancies; the theory was right, but the analytical process was wrong. This position was quite sound, since it was well known that the amount of mineral matter extracted from a soil depends on the nature and strength of the acid; it has since been justified by experience with weak acids. See SOILS, ANALYSIS OF.

The discovery in 1877, by Schloesing and Müntz, that nitrification is due to an organism was the beginning of the application of bacteriology to the study of fertility. Other soil changes were later on found to be brought about by bacteria—oxidation, humification, denitrification, and the nutrition of leguminous plants; and in 1897 Wollny (Die Zersetzung der organischen Stoffe) collected into a comprehensive scheme all the scattered work on these various changes. Two years later Berthelot (Chimie Végétale et Agricole) definitely assigned to bacteria an important function in determining fertility. This view is still being developed; its present position is dealt with in Section III. Bacteria break down the unavailable foodstuff in the soil and convert it into soluble available bodies; in addition, there is a certain amount of nitrogen fixation. No new theory of fertility is involved; bacterial activity simply explains the conversion of material 'unfit for assimilation' into useful plant food.

The United States Bureau of Soils has given up these modifications of Liebig's theory and reverted to some older theories. Whitney in 1892 examined a number of soils of known productiveness, and showed that in passing from type to type the agricultural properties are closely correlated with the texture of the soil as revealed by mechanical analysis. Physical characteristics, and especially texture, regulate the temperature, moisture content, and aeration, in short the 'climate' of the soil, and their significance in determining the distribution and yield of crops must therefore be of the same order as climate in the ordinary sense of the word. They are the predominant factors in fertility. This thesis was further developed in 1898, when typical tobacco soils from the various States were investigated. So successful was mechanical analysis in classifying these soils that it was adopted as the basis of the elaborate soil survey of the whole country. The chemical composition of the soil was supposed to be of very secondary importance, and was dismissed altogether as a factor in fertility in 1903 (Bulletin 22). The solution constituting the soil moisture is regarded as the source of the plant's food; this solution is of the same order of composition and concentration in all soils, such differences as exist could not be correlated with differences in crop production. The function of the soil is to hold up this solution and supply it to the plant; a productive soil is one which supplies it in proper amount, a non-productive soil does not; a productive soil must therefore possess certain physical properties, but its chemical composition is not of primary importance. The common fertilizers are capable of modifying the physical condition of the soil. On the average farm the great controlling factor in the yield of crops is not the amount of plant food in the soil, but is a physical factor the exact nature of which is yet to be determined. Later on, further factors were introduced. In Bulletins 28 and 36 (1907)[1] it is maintained that certain soils are unproductive, not because proper foodstuff is lacking, but because they contain substances actually deleterious to plant growth. Part, at any rate, of the toxic conditions of the soil is transmitted to it from growing plants. The old theory of de Candolle (Physiologie Végétale, 1832) is here revived, according to which plants excrete bodies poisonous to themselves, but not necessarily to others belonging to quite a different order. It is possible to remove these poisonous products in several ways, in particular they are rendered innocuous by the action of dung, lime, and other manures. The function of a fertilizer is not to provide plant food, but to modify the physical properties of the soil, and to put out of action the poisonous bodies secreted by the previous crop, and so to cleanse the soil ready for the next crop.

These later developments are not accepted in Europe, and they are not even universally accepted in the United States.

II. CONDITIONS NECESSARY FOR FERTILITY.—In trying to set out the conditions necessary for fertility we are at once met with the difficulty that fertility is not an absolute property of a soil, but has meaning only in relation to the plants grown on it. Plant requirements vary, and a soil may be fertile in respect to one plant and infertile in respect to others. To take an extreme case, a boggy piece of ground left as indifferent pasture on a farm, and rightly considered infertile, might prove highly productive if planted with azaleas. It is conceivable that every soil might prove ideal for some plant or other, and if all these plants could be grown all soils would be fertile. But in practice the agriculturist can only find use for a very limited number of plants. He therefore has to select those combining the double features of saleability in his markets and suitability to his con-

[1] See also Bulletins 40 and 47 (1907).

ditions. This is one of the first things to be done in a new country. To a limited extent it is possible to bridge the gap between plant requirements and soil conditions; the former may be permanently altered by selection and breeding, as shown by the introduction of strains of mangolds suitable for northern counties, and the latter by such operations as draining, claying, chalking, &c. When all has been done, however, that is economically possible, there may still remain a discrepancy between the conditions ideal for the plant and those it finds in the soil, and the greater this discrepancy the less fertile the soil.

But although plant requirements vary, the difference is in degree only and not in kind, especially if we confine ourselves to the common agricultural crops. We shall therefore first set out the requirements of crops, which are obviously the essential conditions of fertility, and then see how far they are connected with the measurable properties of the soil. The word fertility will be used in its ordinary significance, having reference to the size of the crop rather than to any special quality; the factors connected with high quality are as yet so little known that discussion is unprofitable.

It is generally agreed that the conditions necessary for fertility are (1) a sufficient supply of plant food, both nitrogenous and mineral; (2) *suitable water supply; (3) suitable air supply;* (4) proper temperature; (5) absence of injurious substances. These are all equally important, and to a certain extent are mutually dependent one on the other.

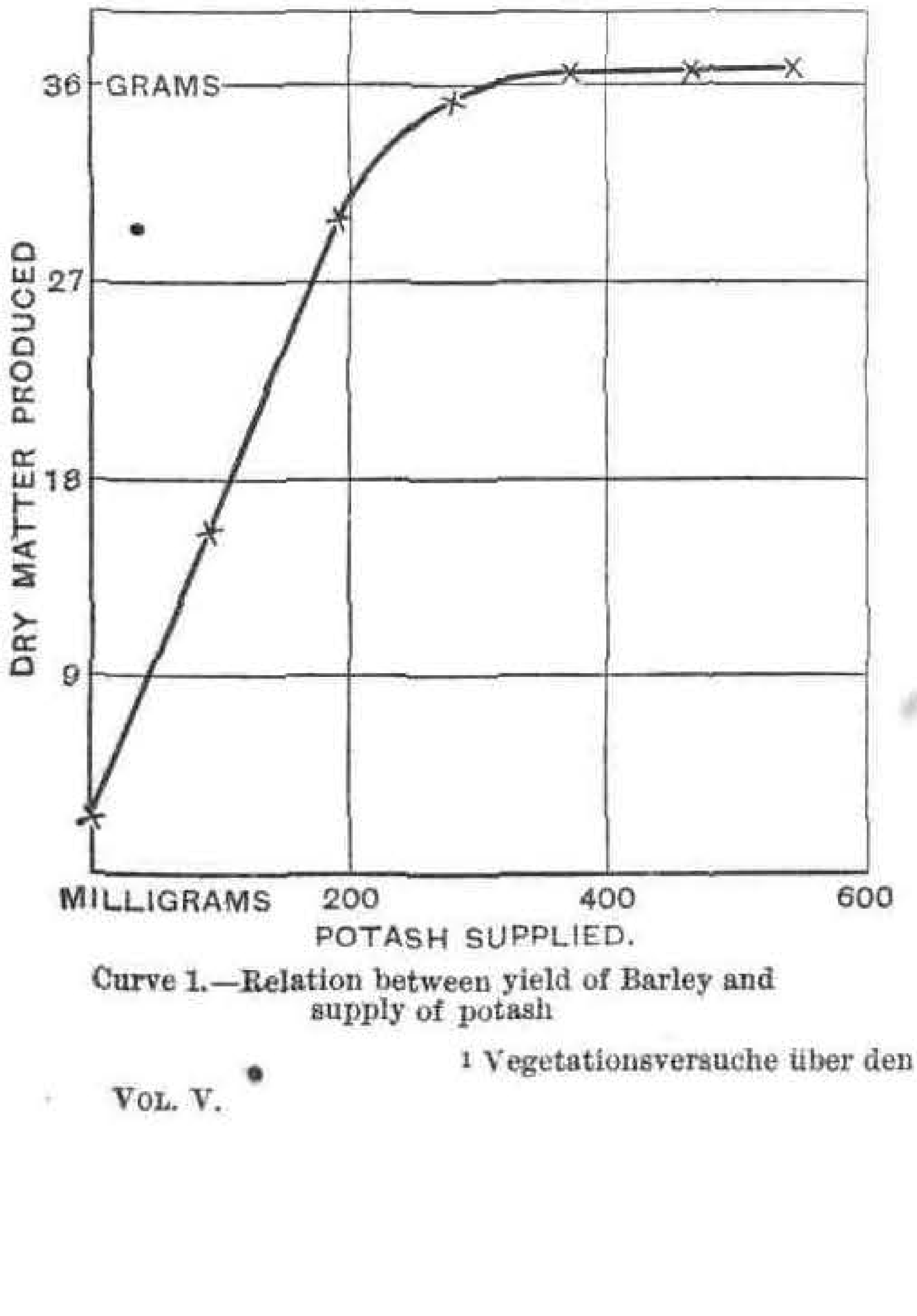
Plant Food. — The substances required as food by plants have been ascertained by water or sand cultures. Seedlings are placed in dilute solutions of various salts, or in pure ; and watered with such solutions; if they grow into perfect plants it is evident that they have been supplied with all essential foodstuffs. If, on the other hand, they fail to develop fully, it is equally clear that something is lacking. By proceeding in this way it has been found that plants must have all of the following elements supplied in suitable combinations: nitrogen, phosphorus, sulphur, potassium, calcium, magnesium, iron. If all these are supplied, plants may ripen and *produce perfect seed; if any one is withheld,* perfect development cannot take place. The following elements in suitable combinations are valuable, but not essential: chlorine, silicon, sodium, and possibly manganese.

All the elements required by plants are widely distributed in nature, and invariably occur in every cultivated soil; but they do not always occur in sufficient amount, for it often happens that the addition of one of them, *e.g.* of phosphorus as phosphate, increases the crop.

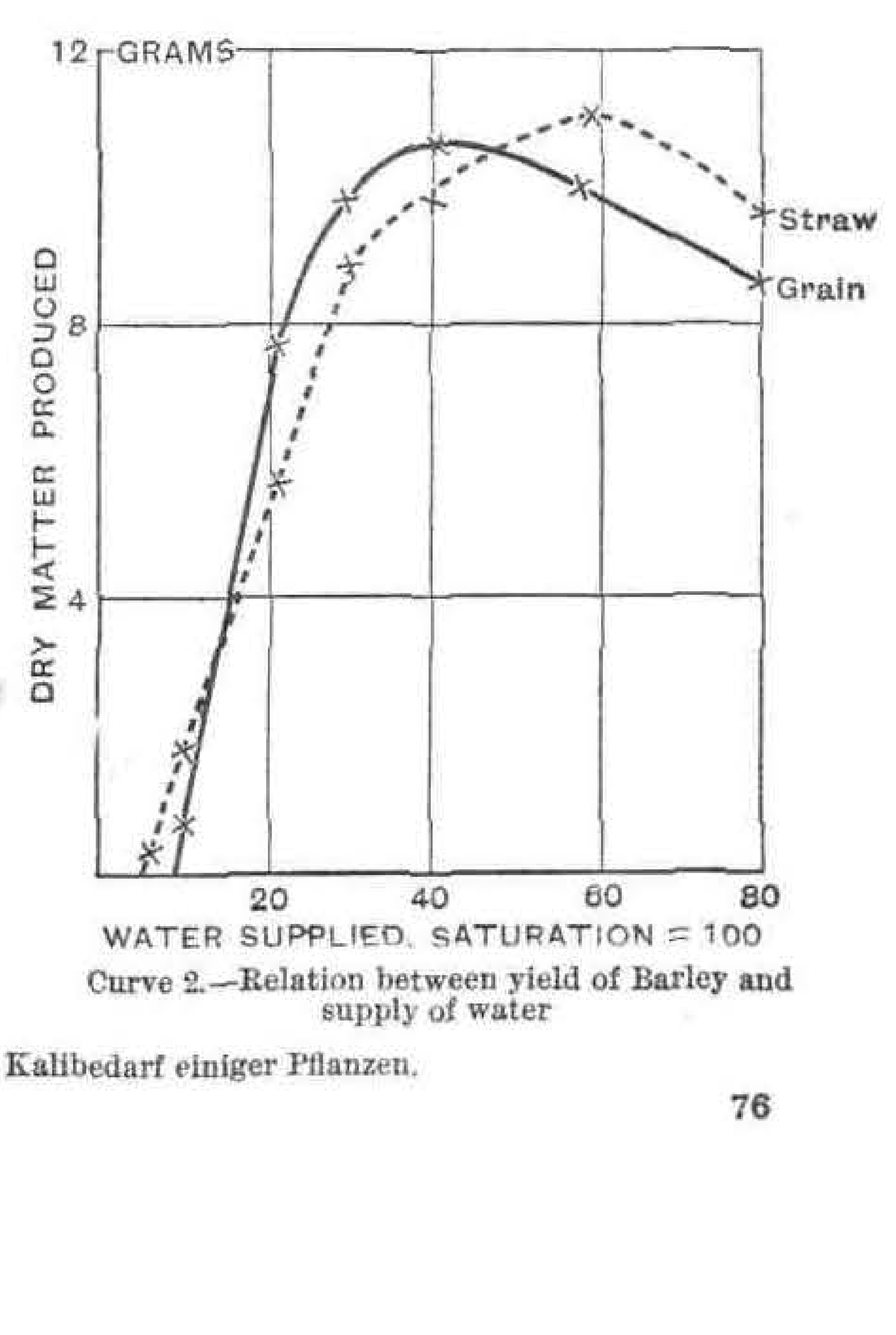
Hellriegel and Wilfarth[1] have made experiments to find the connection between the amount of plant food and the growth of the plant. Barley was grown in a number of pots of sand, each *containing the same amount of all plant foods* except one, which varied in the different pots. In one experiment where potash, supplied as chloride, was the variable constituent, all the rest being constant, the results were:—

Milligrams of potash supplied ...	0	94	188	282	376	470	564
Yield of barley (total dry matter), grams	2·658	15·638	29·724	34·898	36·281	36·584	37·986
Increased yield for each extra 94 mg. of potash		12·980	14·086	5·174	1·383	·303	1·402

Each pot held 4 kg. of sand.



Curve 1.—Relation between yield of Barley and supply of potash



Curve 2.—Relation between yield of Barley and supply of water

[1] Vegetationsversuche über den Kalibedarf einiger Pflanzen.

The results are plotted on the accompanying curve (Curve 1). It will be observed that growth was very small when no potash was supplied; additions of potash increased the crop, and the first two doses of 94 mg. gave an increase of 13 or 14 gm. of dry matter, *i.e.* the increased crop was proportional to the nitrogen added. Beyond this point, however, the gain is less, and falls to *a little over 1 gm. only. This is so generally true* in manuring—and indeed in many other agricultural operations—that it is taken as a law, and spoken of as the Law of Diminishing Returns. A similar relationship was seen in another series of experiments, where the nitrogen varied in amount, but the other foods remained constant; the results were as follows:—

Milligrams of nitrogen supplied ...	0	28	56	112	168	224	336
Yield of barley (*total dry matter*), grams	·461	2·995	5·540	10·802	16·388	21·086	29·343
Increased yield for each extra 28 mg. nitrogen...		2·531	2·545	2·631	2·793	2·349	2·064

Each pot held 4·6 kg. of sand.

Similar results have also been obtained in field trials. On the Broadbalk wheatfield at Rothamsted, Plot 5 receives complete mineral manure but no nitrogen; Plots 6, 7, and 8 receive the same amount of mineral manure, with the addition of ammonium salts containing respectively 43, 86, and 129 lb. of nitrogen. Each extra dose of nitrogen increases the yield, but the last does not cause nearly so great an increase as the first.

BROADBALK WHEATFIELD, AVERAGE YIELDS, FIFTY-SIX YEARS, 1852–1907.

	Plot 5.	Plot 6.	Plot 7.	Plot 8.
Nitrogen supplied in manure, lb. ...	0	43	86	129
Total produce (straw and grain), lb. ...	2315	3948	5833	7005
Increase for each 43 lb. nitrogen		1633	1885	1172

These results all show that fertility is dependent on the presence of plant food, but beyond a certain stage additional plant food does not confer much additional fertility. The yield will now be limited by some of the other factors. *Finally it may be noted that an excessive amount* of plant food is directly injurious to the plant. This condition obtains in some alkali soils.

Water Supply.—*The same relationship* between supply of material and plant growth holds for water as for food. In absence of water, plant growth is impossible; as the supply increases, the amount of growth also increases for a time. Finally, extra water supply causes no extra growth, and when the supply becomes unlimited—as in water cultures—the yield is no heavier than in sand cultures with equal food *but much less water.* Further, *there are two* good reasons why the water in the soil should not be indefinitely increased. In the first place, a large amount of water necessarily diminishes the supply of air; in the second place, it keeps *the temperature down; so that in practice it is* necessary to strike a balance between water, air, and temperature. Hellriegel has ascertained *the proper relationship between water and air* supply for barley under favourable temperature conditions. He found that growth was best when the soil was about half saturated with water; denoting by 100 the quantity of water needed to completely saturate the soil, the amounts present in his various pots and the actual yields of grain and straw were as follows:—

Amount of water	5	10	20	30	40	60	80
Dry matter in grain	nil	·72	7·75	9·73	10·51	9·96	8·77
Dry matter in straw	·12	1·80	5·50	8·70	9·64	11·00	9·47

These figures are plotted on Curve 2.

Perhaps even more important than the actual amount of water is the regularity of the supply, since plants will not tolerate great or sudden variations. This depends on two factors, the amount used by the plant, and the rate at which water can move *in the soil. If these two are* equal, *i.e.* if the soil can steadily replace the water abstracted by the crop, it will be, or can readily be made, fertile. If, on the other hand, the water cannot be replaced fast enough, the crop will be liable to checks, and will depend on timely showers; the soil is now not fertile. The amount of water used by the plant depends, among other things, on (1) the temperature, (2) the size of the crop, (3) the manuring. A large crop requires more water than a small one. Manures that increase the crop therefore increase the amount of water required, but not to *a proportionate extent, since it has been found* that manures economize the consumption of water by plants. Still, the extra water needed is considerable, and is not always forthcoming; in such cases the full increase of crop expected is not obtained. This is especially noticeable on dry soils or in dry seasons. When the water supply is so good that the extra amount is easily

obtainable, the manure will produce its full effect, and the soil is said to be 'responsive' or 'grateful'. Such soils may be, and often are, poor in plant food, but they are more productive than richer soils that do not allow *complete* utilization of the food present. These facts are well illustrated by some of Wilfarth's experiments. He grew sugar beets in pots, keeping them well supplied with water, but also noting how much water they actually used. The pots received varying quantities of nitrates, and the experiment lasted from April to October. The yields and the amounts of water used were as follows:—

Nitrogen supplied, grams	·42	1·26	2·10	2·94	3·36	3·78
Weight of fresh beet produced, grams ...	102·9	314·2	463·4	643·0	839·3	933·5
Weight of dry matter produced, grams ...	23·0	73·9	96·5	132·4	167·6	188·8
Water used (transpired), grams	13100	34570	39420	55190	62600	72280
Stated as inches of rain...	3·6	9·4	10·7	15·8	17·0	19·6

(Biedermann's Zentralblatt, 1905, 34, 167.)

The amount of water required when each pot receives ·42 gm. of nitrogen is equal to 3·6 in. of rain; it increases with the nitrogen supply, and in the most heavily manured pot equalled 19·6 in. In other words, the heaviest dressing of manure could only exert its full effect when 19·6 in. of water is available for the crop; as a rule, less than this would fall as rain during the period of growth, and the balance would have to come from the soil. If the soil could not furnish it, the proper return from the manure could not be obtained, and the heavier dressings would prove unprofitable. On every soil there is a point beyond which manuring cannot be profitably pushed; this point is often fixed by the water supply, especially on light soils. It makes no difference whether the plant food is added as manure or whether it naturally exists in the soil; it is only of use to the plant if the supply of water is sufficient. But we must not make the mistake of supposing that a high rainfall means a high crop: the reverse often happens because a high rainfall is often accompanied by low temperatures (see Table V, p. 234). The most suitable condition is for water to come from underground supplies or in warm rains.

Air Supply. — No soil can be fertile without a sufficient supply of air. Air acts both directly and indirectly: directly, by furnishing the plant root with the necessary oxygen; indirectly, by modifying the bacterial flora of the soil. If the supply is sufficient, proper root development is possible, and the bacterial products are either beneficial, or at least harmless to plants; if it is insufficient the roots are atrophied and the character of the bacterial activity entirely changes, several actually injurious bodies, nitrites, sulphides, and acid organic substances, being liable to arise.

Probably the connection between the amount of air supplied and the crop produced is of the same character as that subsisting between the food or water supply and the crop, but experimental verification is lacking owing to the great difficulty of making the tests. It is commonly stated that an excessive air supply in a soil is harmful, but in reality the bad effects are caused by the looseness of the soil usually, though not necessarily, accompanying copious aeration, and not to the air at all. If the soil is too loose, plants fail to get proper root hold and their water supply becomes irregular, since the capillary films of water move freely only in fairly compact soil.

Temperature. — The relation between plant growth and temperature differs only in degree from that given for food. There is a lower limit, below which growth does not take place. As the temperature rises, growth becomes much more rapid till a certain temperature, spoken of as the *optimum*, is reached; beyond this point growth becomes rapidly less, and finally the plant is killed. No experimenter has measured the actual amount of growth at different temperatures, but Miss Matthaei has determined the amount of assimilation, which is closely parallel to growth. A cherry laurel leaf was found to assimilate the following weights of carbonic acid per 50 sq. cm. (about 8 sq. in.) per hour:—

Temperature, degrees C.	−6°	+8·8°	11·4°	15°	23·7°	30·5°	37·5°	40·5°	43°
Weight of CO_2 assimilated, grams ...	·0002	·0038	·0048	·0070	·0102	·0157	·0238	·0149	·0102

The results show that assimilation takes place even below the freezing-point, but very slowly; it increases rapidly above 9° C., and reaches a maximum at 37·5°; it then slows down, and at a somewhat higher temperature death takes place. The results at the lower temperatures are of more immediate interest now, for the temperatures obtaining in the soil are generally low. Between 9° and 15° the temperature gradient is steep, assimilation nearly doubled, and growth would probably show a somewhat similar increase. The higher the soil temperature the greater the amount of growth, even a difference of 1° only may be expected to produce quite distinct differences in productiveness, *provided a sufficient water supply is available.* This condition is usually fulfilled on loams and clays, and here it commonly happens that the soil temperature is the factor controlling the yield and fixing the point beyond which manuring ceases to be profitable. On light soils, however, and sometimes also on heavier ones, the beneficial effect of a higher temperature may be masked by the loss of water due to increased evaporation.

Absence of Injurious Substances. — This aspect of fertility is being investigated by the

United States Bureau of Soils, but the experimental difficulties are very great, and little is yet known with certainty about it. The difficulty arises from the complex nature of the soil, and from the fact that soil is not an inert mass, but contains chemically active bodies, and teems with micro-organisms continually bringing about changes and decompositions. It is easy to show, by means of water or sand cultures, that a large number of substances are injurious to plants, but the effect depends on the amount used, and is modified by the presence of other bodies. It is possible that among the numerous constituents of soil some may in themselves be of a harmful nature, but they do not necessarily exert a harmful effect in the soil, because some other constituent may either react with them, throw them out of solution, or mask their effect.

There are, however, some well-established cases of harmful bodies occurring in the soil.

Toxic Mineral Substances. — 1. *Soluble Alkaline Carbonates (Potassium and Sodium Carbonates) in Alkali Soils.* — This case has been fully investigated by Hilgard. He found that, under favourable conditions, gypsum (calcium sulphate) reacts with these bodies, converting them into sulphates, which are only harmful if present in excessive amounts, and calcium carbonate, which is directly useful to the plant. The method of treatment he devised is based on this reaction, and is found to be very effective. See art. Alkali Soils.

2. *Magnesium Compounds.* — Loew and his pupils in America and Japan have studied this question. Magnesia in suitable combination is essential to plants, but too much is harmful, and it sometimes happens that an excessive amount is present in the soil. Lime has been found to overcome the injurious effect, but for what reason is not clear, for there does not appear to be any chemical change; Loew's view is that the constituents of the protoplasm are deranged unless there is a proper excess of lime over magnesia. This excess has been determined for a number of plants; for cereals the most favourable ratio is said to be

$$\frac{\text{lime} = 1 \text{ to } 1{\cdot}5}{\text{magnesia} = 1},$$

while plants with abundant foliage require twice or four times as much lime as magnesia.

3. *Iron Compounds.*—For many years it has been customary to suppose that certain iron compounds in the soil are injurious, and as far back as 1808 Arthur Young, jun., ascribed the sterility of some of the Sussex soils to the 'ferruginous mixture with which the soil of this county is in many places so highly impregnated'. Later writers have stated that ferrous compounds are toxic, whilst others maintain that they are useful manures. The bad effects observed may be due to the defective aeration which gives rise to ferrous compounds. The question is discussed in the art. Iron Compounds in Soils.

Wherever sterility has been ascribed to iron salts, it is found that applications of lime and drainage are beneficial.

Toxic Organic Substances.—If aeration of the soil is insufficient, the anaerobic organisms predominate and the decomposition processes alter; products are formed which do not normally appear. At the same time, also, plant growth suffers; in pastures some of the species disappear and others take their place, so that the character of the herbage changes. It is therefore supposed that some of the decomposition products are toxic, but the evidence is not conclusive, and the ill effects may also be due to the altered physical conditions, lack of air, &c. Liming is found to be exceedingly beneficial.

The United States Bureau of Soils state that the sterility of certain soils which have come under their notice is due to the presence of toxic organic substances (see Bulletins 28, 36, and 40, 1907). These are soluble in water, and an aqueous extract of the soils in question proved toxic to wheat seedlings; they are, however, removed by charcoal, ferric hydrate, and other finely divided solid bodies. Dung, lime, and other fertilizers also appear to remove them, or at any rate to reduce their toxicity. See previous section, 'Historical'.

Substances Harmful only in Excess.—*Soluble Salts.* — When the rainfall is insufficient and the temperature fairly high, soluble decomposition and disintegration products may accumulate in the soil to such an extent that growth is impossible. Nothing is actually poisonous, but in presence of the excess of soluble matter plant roots will not function properly. This case is discussed in the art. Alkali Soils.

Chalk.—French vine growers have long known that vines growing on calcareous soils suffer much from chlorosis, and this disease is attributed in France to the excess of chalk.[1] Chauzit analysed soils on which American vines became chlorotic and others on which they did not, and found the following percentages of lime:—

Soils liable to Chlorosis

	Per cent of lime.
Maine-Neuf (Grande Champagne) ...	48·53
Écurolles (Charente Inf.)	44·67
Julliac-le-Coq (Charente)	43·66
Verchant (Hérault)	35·25

Soils not liable to Chlorosis

	Per cent of lime.
La Ciotat (Bouches du Rhône)	·680
Tout y Faut (Charente Inf.)	2·125
Lédenon (Gard)	3·670
Pezilla (Pyrénées Orientales)	8·790

(Revue de Viticulture, 1902, 18, 15; see also Molz, Centralblatt für Bakt., II abt. 1907, 19, 475).

III. The Relationship between the Properties of the Soil and its Fertility.—Having discussed the conditions essential to fertility, we now turn to the effect on fertility of the more striking properties of the soil. We shall study the effects of (1) mechanical composition, (2) situation, (3) nature of the subsoil, (4) chemical composition, (5) bacterial flora. We shall find them somewhat variable, but two guiding principles hold throughout—(*a*) all the plant requirements must be fulfilled, and (*b*) deficiency of one

[1] See Roux, J., Traité des rapports des plantes avec le sol et de la chlorose végétale; Paris, 1900.

cannot be made up for by excess of others. Hence the productiveness of the soil may be limited by any or all of the five factors discussed in the last section.

The Effect of the Physical Composition on the Fertility of Soils.—The physical composition of the soil gives a measure of the proportion of its particles[1] falling between certain limits of diameter; it is thus concerned with the size of the particles, and not at all with their nature, and is to be correlated with the physical rather than the chemical properties of the soil. Of all the characters of the soil this is one of the least amenable to permanent change. The chemical character of most soils can be modified or even entirely altered by the addition of suitable materials: the bacterial flora can often be changed by adding lime or organic matter; but the physical composition is only changed by adding extremely large dressings of sand or clay such as would not be attempted in practice. Of course, it is possible by suitable means to bring about temporary changes: thus a great improvement in the texture of a sticky soil may be effected by liming, by adding organic matter, or by skilful cultivation; but such changes are due to the added material, and to the regulation of the 'condition' of the soil (see art. SOIL).

The chief direction in which the physical composition of the soil affects its fertility is in its various relationships to water. The ease with which water moves about in the soil, to replace what is taken by the plant or lost by evaporation, depends on its physical composition, so that a knowledge of this down to the permanent water level, or even for the first few feet if the soil is not too light, gives valuable information as to the supply of water available for the plant. Coarse particles make the soil porous, and so facilitate the downward percolation of water, the movement of air into the soil, and the diffusion of water vapour out of it; hence also they tend to raise the soil temperature in spring and early summer; their effect is therefore to warm and aerate the soil, but also to dry it. Having no power of cohesion, they do not become sticky when wet; they therefore check panning and facilitate cultivation, so that they are said to lighten a soil; they also offer no resistance to root development. Being composed largely of silica, they have no action on ammonia or organic substances; they therefore cannot 'fix' manures. On the other hand, fine particles make the soil retentive of water, partly by mechanically impeding the downward flow, and partly because their large total surface enables them to hold a larger amount of water by surface tension than could the same weight of coarse particles; for this reason also they can lift water from the subsoil to a greater height than coarse particles could. The finest material, the clay, swells and becomes sticky when wet, thus rendering the soil liable to pan down and to dry into clods; it also increases the difficulty of working, *i.e.* makes the soil heavy. On drying it shrinks and may cause cracks. It reacts with ammonia and soluble organic substances in the soil to form insoluble combinations; thus it 'fixes' manures. Fine particles therefore tend to produce steady water and temperature conditions, and are consequently highly conducive to fertility; when the finest material is present in excess, however, it seriously impedes the movement of air and water in the soil, and makes the soil too sticky for cultivation or root development.

An ideal soil will therefore contain suitable proportions of coarse and of fine particles, neither being in excess. We now turn from these general principles to a few actual examples of soils. It is generally found that 40 per cent or more of coarse sand (1 mm. to ·2 mm. diameter) results in so much loss of water that the soil is unproductive, however good the chemical composition; indeed, some of these soils have never been taken into cultivation, as, *e.g.*, Soils 1 and 2 in the table, waste sands in Suffolk and Kent respectively. But if the percentage of clay exceeds 6 or 7, then the bad effect of the coarse particles is so modified that cultivation becomes possible, and provided the water level is not too far down, and the addition of organic matter by dung or green manuring is feasible (for organic matter helps to overcome the bad effect of coarse particles in excess), they may be made very productive. Their chief advantage, however, is either their earliness or the quality of their produce, and they are better adapted to special crops, like early potatoes, market-garden produce, or malting barley, than to ordinary farm crops. Soil 3 is an instance. It is a Kent market-garden soil from near Swanley, and when heavily dressed with dung it yields admirable crops of potatoes, green vegetables, &c. Such soils are more correctly described as 'responsive' than fertile. Great improvement results, however, as the amount of coarse sand decreases and the proportions of fine sand and silt increase, so long as the clay does not unduly increase; the most fertile soils are found in this class. They can raise water by surface tension through great distances, and are practically always moist in summer. Soil 4 is a rich alluvial soil from near Chichester, one of the most fertile tracts of Great Britain, and Soil 5 is one of the best hop gardens in Kent. Soils 6 (*a*) and (*b*) are very fertile loams, regularly producing crops well above the average; these soils probably represent the ideal mixture of particles for the conditions obtaining in the south-east of England. If the clay increases above 12 or 15 per cent the movement of water is impeded, and during hot weather plants may wilt, even though the water level is quite near to the surface; the amount of calcium carbonate (which flocculates the clay) now becomes a very important factor. The heavier loams and the clays come into this class. Soil 7 is a loam (Rothamsted), and Soil 8 is a clay from the Surrey London Clay, which cracks badly in summer, and is so sticky in winter that cultivation is always difficult. So long as the coarse particles are present in sufficient amount these soils can always be kept as arable, though grass may entail less trouble and be found more profitable. Many of the old wheat and bean soils come into this class. But as the coarse

[1] For method of measurement see SOIL, ANALYSIS OF.

particles decrease, cultivation becomes more and more difficult, and is now often not attempted, the fields being laid down to permanent pasture. Soil 9 is an instance. Finally, when the coarse particles are practically absent and there is a large proportion of clay, the worst and most hopeless type of soil is reached. Many of these soils have never been cultivated at all, but have remained as common or forest land even in the most populous and highly farmed districts; such is Soil No. 10, representing the stiffest London Clay of East Kent.

TABLE I.—MECHANICAL ANALYSIS OF VARIOUS SOILS

Name of fraction.	Diameters of particles.	No. 1.—Waste sandy soil, Suffolk.	No. 2.—Waste land (Hayes Common), Kent.	No. 3.—Market garden soil, Swanley, Kent (Thames bed).	No. 4.—*Very fertile soil*, near Chichester (brick earth).	No. 5.—Very fertile soil, hop garden, Kent (Hythe beds).	No. 6.—Good loams (brick earths), Kent. (a)	No. 6.—Good loams (brick earths), Kent. (b)	No. 7.—Fair loam, Rothamsted (Broadbalk unmanured plot).	No. 8.—Heavy clay (London Clay).	No. 9.—Heavy clay (Weald of Kent).	No. 10.—Clay too heavy to cultivate (London Clay).
Stones	Above 3 mm.	Nil.	14·7	2·54	Nil.	9·19	1·56	Nil.	—	2·12	·55	—
Gravel	3·00 mm. to 1·00 mm.	6·82	6·85	1·20	·97	3·15	1·04	·30	1·6	·61	·87	·40
Coarse sand..	1·00 mm. to ·2 mm.	56·89	12·87	10·27	1·35	9·52	3·07	·72	7·1	12·82	1·52	·81
Fine sand ...	·2 mm. to ·04 mm.	28·35	36·18	58·68	24·03	30·63	27·26	24·71	21·0	25·54	8·74	6·36
Coarse silt ...	·04 mm. to ·01 mm.	2·29	16·06	13·37	35·50	19·67	40·07	44·84	33·3	11·30	13·70	15·84
Fine silt ...	·01 mm. to ·002 mm.	1·05	8·33	5·10	13·39	11·16	8·93	8·68	14·1	11·13	31·62	16·37
Clay ...	Below ·002 mm.	1·76	3·37	5·52	15·91	13·35	11·25	14·77	18·3	23·75	27·83	40·52
Organic matter ...	—	1·71	15·05	4·00	11·02	4·46	5·56	4·65	4·2	5·61	9·24	9·08
Calcium carbonate ...	—	·05	·05	·02	·75	3·20	·18	·40	3·3	·20	·84	·35

The physical composition of the soil affects its temperature, *as has already been stated*, and light soils like 1 and 2 are warmer than heavier ones like 5 and 6; but so far as the measurements go, the differences do not appear to be very great. Mellish has compared the mean temperature of the soil 1 ft. down at seven stations on sandy soils with that at seven others on clay soils, and his results show that light soils are about 1° F. warmer than heavy ones, particularly in spring and summer.

TABLE II.—EXCESS OF TEMPERATURE OF THE SOIL AT 1 FT. DEPTH OVER THE MEAN TEMPERATURE OF THE AIR, DEGREES F.

	Jan.	Feb.	Mar.	April.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Whole year.
Light soils	+ 0·9	+ 0·3	− 0·7	+ 0·2	+ 1·1	+ 1·2	+ 1·6	+ 1·2	+ 1·1	+ 1·9	+ 1·5	+ 1·6	+ 1·0
Heavy soils ...	+ 0·2	− 0·7	− 0·8	− 0·8	+ 0·1	+ 0·2	+ 0·4	+ 0·4	+ 0·5	+ 1·4	+ 0·7	+ 0·9	+ 0·2
Difference in favour of light soil	+ 0·7	+ 1·0	+ 0·1	+ 1·0	+ 1·0	+ 1·0	+ 1·2	+ 0·8	+ 0·6	+ 0·5	+ 0·8	+ 0·7	+ 0·8

(Jour. Roy. Met. Soc. 1899, 25, 238.)

They are also warmer in autumn and winter, but not quite to the same extent.

Effect of the Situation of the Soil on its Productiveness.—The situation of the soil profoundly affects its water supply and temperature, and is of very great importance in regulating its fertility; indeed a large number of soils owe much of their fertility to their position.

Effect on Water Supply.—When rain falls on the surface of the earth, a certain amount soaks in and travels downwards, but some follows the slope of the land and comes out again at a lower level. The highest land receives only the rain which actually falls upon it, the lower land not only receives its own proper rainfall, but also some of the water which has soaked through from above. At the bottom of the slope the water supply is at its highest, and according to the position of the water level we shall find a river, a marsh, or moist, productive land. The effect on productiveness depends on the nature of the soil. Taking first the case of light sandy or chalky soils, these readily allow water to run through, so that the water supply of the highest land is irregular; it is ample whilst rain is actually falling, but may become very deficient shortly afterwards as a result of excessive drainage. Such variations in the water supply are not tolerated by plants, and these high lands are therefore unproductive, sometimes even barren wastes.

The lower land, however, receives some of the water which has soaked through from above in addition to its own share of rainfall. The soaking process is slow, and makes itself felt for some time after the rain has ceased; in suitable

circumstances the land may not dry out at all. This condition is eminently favourable to vegetation, and some of the most fertile soils are found on slopes of this kind. Moreover, the water soaking through from above is more than pure water; it has in its passage through the soil dissolved a certain amount of mineral matter—sometimes as much as ·1 per cent—part of which is valuable plant food. The process constitutes a natural sub-irrigation, and is particularly effective where the physical texture of the soil allows water to be drawn up to the roots as quickly as required.

At the bottom of the slope the water supply is at its highest, and the productiveness depends on the water level. Where this is near, but below the surface, the land will probably be very fertile, even though the soil may not appear on examination to be particularly good. If the water level is too near the surface, the land may be cold and late in spring, or it may be marshy. This condition is bad for fertility, but can be at once remedied by lowering the water level.

One effect of rain on a slope is to wash the finest particles downwards, and in the course of ages the valley receives so much of these that the nature of its soil changes, the texture becomes finer, and there is a better power of retaining water. In consequence the fertility of the lower slopes is still further increased. The proverbial fertility of valleys may therefore be ascribed to three causes: the percolation of water, the transference of soluble matter from the higher to the lower ground, and the downwash of fine soil particles. The higher land is slowly but continuously impoverished, while the lower tends to gain in productiveness, the process being of course exceedingly slow. On a small scale these effects can often be seen in very light sandy fields. If one part lies higher than the rest it has a smaller supply of water, and is less likely to be productive.

In applying the above considerations to heavy soils, it must be remembered that these tend to suffer from excess of water and low temperature; hence the effect on fertility may be the reverse of what we have just seen, and the higher well-drained ridges and banks be more productive than the lower moister levels. This case is not really an exception, it is simply the result of too great a supply of one of the chief requisites for fertility. Complications may further result if a stratum of impermeable clay or rock crops out somewhere on the slope, but the same fundamental principles hold.

Effect on Temperature.—(*a*) *The influence of elevation.*—As a rule, the higher one ascends the lower is the mean temperature, and above a certain height the coldness, together with the liability to strong winds, produces so adverse an effect on plant life that most crops suffer, and some will not grow at all. Thus in Kent 500 ft. is considered to be the limit above which hops cannot be produced. The rule requires some modification, however, when the elevation is not too high. Comparing two stations, one in the valley and the other 200 or 300 ft. higher in altitude, the lower one is hotter by day but colder by night than the higher. Valleys and low-lying soils are liable to the 'late frosts', which are so injurious to fruit and early potatoes. The effect is modified near a river, and the cooling at night is not so great; 'late frosts' are therefore avoided. It is well recognized in North Kent that land situated on the coast (*e.g.* the Isle of Grain) is more suited for early potatoes than land a little farther from the water; so also orchards close to the coast suffer less from frost than those inland.

(*b*) *The influence of aspect.*—A south slope is warmer than a north slope, and crops will therefore make an earlier start and ripen more quickly. Where early crops are required, a south slope is the best situation for them, and in certain special districts this is so well recognized that a south slope commands a higher rent; *e.g.* in Jersey, where early potatoes are exceedingly profitable, the south slope is often considerably dearer than a north slope. But for ordinary farm crops the difference in value is not great. The south slope is certainly warmer, but it may for that reason become drier, and on light soils the south slope may become parched during a hot summer, while the cooler north slope is still sufficiently moist for vegetation.

The Effect of the Subsoil on Productiveness.—The subsoil down to the water level is an important agent in determining fertility, chiefly because of its effect on the water supply. If it is too coarse, the surface soil may be overdrained, and crops are liable to dry out in summer; if, on the other hand, it is too heavy, drainage may be insufficient, and the surface soil will be too wet. This case can, of course, be met by an artificial system of drainage. The conditions most favourable to a good water supply are realized when a good surface soil (*e.g.* Soils 4, 5, and 6 in Table 1) lies on a slightly heavier subsoil. Any excess of water can then drain away, but a sufficient quantity is always available for the needs of the crop. In addition, the plant has abundant space for copious root development, and can thus draw on a great volume of soil for food and water. On the other hand, some of the worst cases of infertility arise when the surface soil is too shallow, *i.e.* when a subsoil unsuited to root growth is too near the top; here we have poor root development and irregular water supply.

The Effect of the Chemical Composition on the Fertility of the Soil.—The chemical constituents of the soil influencing its fertility are:—

(*a*) The foodstuffs: potash, phosphoric acid, nitrogen, &c.

(*b*) The organic matter.

(*c*) The calcium carbonate.

The relationship between any of these and fertility could probably be expressed in a general way by curves like Curve 1, *i.e.* the fertility increases with the amount when small quantities only are present, but beyond a certain point further increase in amount causes no increase in fertility, though it may be valuable as a reserve.

The Foodstuffs.—1. *Potash.*—We begin with potash, because it seems to constitute the simplest case. So far as is known, all the potassium compounds in the soil are of the type KX, dissociating into ions K and X or hydrolysing to KOH and HX, where X is a complex silicate group.

They are therefore all potential plant foods; their utility depends solely on their solubility in soil water and on their amount—or more strictly, their active amount or surface. In fact, we might define the effectiveness of each potash compound in the soil as the product of its surface and its solubility in soil water. The total effectiveness is the sum of all these products. *Unfortunately no practicable way of determining* this has yet been suggested. Instead, it is customary to determine the amount soluble in water containing 1 per cent of citric acid or charged with carbonic acid—generally the former—and speak of it as the 'available' potash. The method has no sound foundation in principle, but it can be easily worked, and is therefore of more practical value than the theoretically correct method.

Adopting this new criterion—solubility in 1 per cent citric acid—we get a simple, but not absolutely exact relationship to fertility. Generally speaking, the greater the amount of 'available' potash the greater the fertility, but there are well-marked exceptions, because our method is imperfect. Some illustrative figures are given in *Table III.*

It will be remembered that plant growth increased with the supply of food, especially for the first few additions of plant food, *i.e.* at the beginning of the curve. An important practical problem is to ascertain when the amount of potash in the soil is so low that the conditions resemble those at the beginning of the curve, where a small additional amount of potash may exert its full benefit in increasing plant growth. Experience has shown that these conditions are realized when less than ·01 per cent of potash is present; in such cases potassic manuring is likely to be beneficial, especially on light soils.

2. *Phosphoric Acid.*—This case is a little more difficult because the phosphorus compounds are not of the simple type PX, but are much more complex, since the phosphorus always occurs in a complex ion. Moreover, only a phosphate, *i.e.* the ion PO_4, is of any use to plants. It is therefore first of all necessary to mark off the phosphates from the other phosphorus compounds of the soil. Having done this, we can apply the remarks given above for potash. The same definition of effectiveness holds, and since the ideal method is impracticable, recourse is had to extraction with dilute acid—generally 1 per cent citric acid.

The average amounts of phosphoric acid and of potash extracted from various Kent and Surrey soils by 1 per cent citric acid and by strong hydrochloric acid are given in Table III.

TABLE III.—PHOSPHORIC ACID AND POTASH IN KENT AND SURREY SOILS

	Phosphoric Acid (P_2O_5).		Potash (K_2O).	
	1% Citric Acid.	Strong hydrochloric acid.	1% Citric Acid.	Strong hydrochloric acid.
Alluvial	·015	·10	·01	·37
Chalk	·012	·18	·01½	·50
Clay and loam (average of all) ...	·014	·11	·014	·54
,, (waste)	·007	·11	·016	1·0
Fertile loams	·025	·15	·011	·35
Sand (average of all)...	·030	·13	·017	·47
,, (waste)	·010	·07	·010	·14
Fertile sandy soils	·040	·12	·020	·50

In the case of clays and loams the fertility increases with the amount of phosphoric acid soluble in 1 per cent citric acid, but has no connection with the amount of potash, indicating that excess of the latter is present; whilst in the case of sandy soils the fertility increases both with the phosphoric acid and the potash soluble in 1 per cent citric acid, indicating insufficiency of both. This fact agrees with the usual experience that clays and loams require phosphatic rather than potassic manuring, whilst sands require both.

It is usually found that cereal crops resp nd to phosphatic manures when less than ·01 per cent citric acid soluble is present,[1] and grass land when there is less than ·02 per cent.[2] Like the corresponding ·01 per cent limit for potash, *however, these figures have no absolute value,* but are useful in suggesting schemes of manuring. Regard must always be had to the effect of the fertilizers. Potash tends to prolong the life of the plant, and is therefore more likely to be effective on light, sandy, or chalky soils, where the conditions tend to shorten it, than on heavier soils, where the tendency is already to prolong growth. The limit for profitable manuring may the efore be above ·01 per cent on a light soil, ana somewhat below it on a heavier one. Phosphates tend to produce root development at the beginning, and favour the ripening process at the end of the plant's life. They are therefore of special use where the other conditions are so favourable to leaf and stem development that extra root growth is worth securing, and where it is necessary to aid the ripening processes. These conditions obtain on clays, loams, and some light soils well provided with water. Phosphatic manuring may therefore be useful even *when the above limits are exceeded.* On the other hand, dry light soils are often so favourable to fine root development and to ripening, even when the phosphoric acid falls below these limits, that phosphates may give no profitable return. Further, soils with a large amount of organic matter may contain their phosphorus

[1] Dyer, Phil. Trans. 1901, 194, 250; also Hall and Plymen, Trans. Chem. Soc. 1902, 81, 118.
[2] Wood and Berry, Journ. Agric. Science, 1905, 1, 114.

mainly in organic combinations useless to plants, and be very poor in phosphates. Since the analytical processes do not sharply distinguish between phosphates and other phosphorus compounds, the results often indicate a higher proportion of 'available' phosphoric acid than is actually present; the limit therefore has to be raised so much that the method breaks down. Thus the moor soils of the island of Gothland (Sweden) appear from analysis to contain a fair amount of 'available' phosphate, but actually do not, for they are found to respond wonderfully to phosphatic manures;[1] so also do the peaty soils of the Isle of Ely, which contain as much as ·05 per cent of phosphorus compounds, called in the analysis 'available phosphoric acid', but clearly not 'available'.[2]

3. *Nitrogen.*—Of the numerous nitrogen compounds in the soil, only one or two—nitrates and perhaps ammonia—are directly concerned with its fertility, since they alone can be utilized by plants. Some of the others are converted into these two by the action of micro-organisms, and must therefore be taken into account, but the rest appear to resist this attack, and to contribute little or nothing to the plant food. It follows that fertility does not depend on the total amount of nitrogen, but only on those compounds capable of being readily converted into ammonia. No analytical method for discrimination between this 'available' nitrogen and the 'unavailable' part is in use, it being supposed that the 'available' increases with the total amount. While this is generally true, it is by no means a universal rule, as shown by the following analyses of the soils already referred to:—

TABLE IV.—PERCENTAGE OF NITROGEN IN VARIOUS KENT AND SURREY SOILS

Pasture Soils

Alluvial	·54
Clay and loam pastures ...	·25

Arable Soils

	Average.	Very fertile.	Waste lands (commons).
Chalk	·25	·32	·45
Clay and loam ...	·16	·20	·33
Sandy	·15	·18	·43

[Very exhausted arable, Rothamsted unmanured wheat plot, ·09.]

The general sense of these figures is clearly that the fertility increases with the amount of nitrogen: the most fertile soils, the alluvials, contain most, and the least fertile soils, the sands, contain least. But there are two well-marked exceptions. Chalky soils, which are not usually reckoned very fertile, contain a high percentage of nitrogen; and waste land (commons, &c.) contain more than fertile soils of the same type. The explanation is not quite clear, especially for the chalky soils; in the case of the waste lands, one may suppose that the conditions are not favourable to bacterial activity, and therefore the loss of nitrogen is reduced to a minimum.

There is no doubt a connection between the amount of nitrates and the fertility, but sufficient determinations have not been made; further, the fluctuations during the year are considerable. It is simpler and more accurate to ascertain the rate at which nitrates are produced. This is discussed in a later section.

Organic Matter.—The organic matter, or combustible material of the soil, arises from the remains of plants and animals. It furnishes food for worms, insects, and the enormous number of micro-organisms of the soil, and is by them converted into a variety of more or less complex bodies, of which a black indefinite substance known as humus is the one mainly concerned with soil productiveness. *Excepting* as the source of humus, undecomposed organic matter is of little value. It may serve a useful purpose on a heavy soil by keeping the soil open; but on light soils it is positively harmful, because it opens them up too much, and allows moisture too readily to evaporate. Humus, on the other hand, affects fertility in several ways: (1) it furnishes a supply of nitrogen for the plant; (2) it holds up water, which is therefore prevented from running off into the subsoil; and (3) it modifies the texture of the soil, and so improves the tilth. The value of the organic matter, therefore, depends entirely on the rate at which it is converted into humus, *i.e.* on the activity of the organisms in the soil. Illustrations of the ease with which humus breaks down to form nitrates are given in the art. NITRIFICATION; it is sufficient now to point out that the decomposition goes on rapidly, furnishing a constant supply of nitrate to the plant, and that the rate increases as the soil warms, *i.e.* as the plant grows and requires more nitrate. So important a part does humus play in determining fertility that it has often been looked upon as the chief factor, *e.g.* it was so regarded by the late Sir John Lawes in his Letters on Fertility.

The water-holding power of humus is well illustrated by the following determinations of water in neighbouring Rothamsted plots respectively rich and poor in humus:—

PERCENTAGE OF WATER

	Broadbalk wheat field.[1]		Hoos barley field.[2]	
	Surface soil rich in humus (dunged plot).	Surface soil poor in humus (unmanured plot).	Surface soil rich in humus (dunged plot).	Surface soil poor in humus (unmanured plot).
0 in. to 9 in. ...	19·3	16·0	20·7	17·0
9 in. to 18 in. ...	17·0	19·8	17·7	22·5
18 in. to 27 in. ...	18·4	23·3	18·3	22·1

[1] Samples taken, October 13, 1904; ·262 in. of rain fell on October 12, but nothing for nine days previously.

[2] Samples taken, October 3, 1904; ·456 in. of rain fell on September 30, but practically nothing for fifteen days previously.

[1] Investigated by Nilson, whose fullest papers are abstracted in the Jahresberichte der Agrikulturchemie for 1889 and 1896; see also Trans. Chem. Soc. 1900, 77, 1277.

[2] Cambridge Experiments, 1906, p. 12.

In each case the surface soil rich in humus contains over 3 per cent more water than the surface soil poor in humus; the lower depths in the former case contain less than in the latter, because the water has been held to the surface instead of running through. The result is that in dry years the dunged plots have an advantage over the others, which shows itself in an increased crop. In wet years, however, all plots are equally well supplied with water, and the difference in crop is less. The average yield of wheat on the dunged plot (Plot 2) and on one receiving a complete manure but no organic matter (Plot 6) for seven dry years (rainfall below 23 in.) and seven wet years (rainfall above 28 in.) is as follows:—

Table V.—Yield of Wheat in Wet and Dry Seasons

	Average Rainfall.	Grain in Bushels.		Increase on Dunged Plot.	
		No Dung. Plot 6.	Dung. Plot 2.	In Bushels.	Percentage Increase.
	Inches.				
Seven dry years	22	23½	40¼	16¾	74
Seven wet years	31·3	22½	35½	13	58

Straw in Cwts.

	No Dung. Plot 6.	Dung. Plot 2.	Increase on Dunged Plot.	
			Increase in Cwts.	Percentage Increase.
Dry years	21¼	38½	17¼	80
Wet years	19	32	13	68

The rainfall is counted from September to September. The years were—Dry, 1880, 1887, 1891, 1893, 1896, 1898, 1899; wet, 1882, 1883, 1886, 1888, 1889, 1897, 1900.

The effect on the tilth is especially noticeable on soils inclined to be sticky. It is strikingly shown on the Rothamsted mangold plots, those receiving organic matter being readily got into a good tilth, whilst on some of the others receiving none the tilth is so bad that the young plants often fail in spite of much transplanting. On very light soils, too, the effect is marked.

The nature of the influence of humus on fertility will therefore depend very much on the texture of the soil and its supply of water. Where these are both good, humus simply provides plant food; where one or other is bad, humus will, in addition, tend to remedy the defect. A soil of the former type, *i.e.* with good texture and good water supply, would still be 'responsive' even if it possessed but little organic matter; but a soil of the latter type, *i.e.* too sticky, too light, or too dry, is practically useless without humus. And as the rate of decomposition of organic matter is only slow, the improvement effected by adding it is very lasting. Both at Rothamsted and at Woburn it has been shown that land which has received a few dressings of dung will show the effect for many years afterwards.

Since humus is only a transition product, the really important factors are the total amount of organic matter in the soil, and the rate at which the organisms convert it into humus, which in turn is greatly influenced by the amount of calcium carbonate present, as well as by the nature of the organic matter and the general conditions of the soil. We must not, therefore, look for any simple connection between the amount of organic matter and the fertility of the soil; a glance at Table I will show the absence of any such connection; indeed the very fertile Soils 5 and 6 contain even less organic matter than the much less productive Soil 9. Probably when less than 3 or 4 per cent is present, one could trace a rough proportionality between the amount of organic matter and the fertility; but when more than this quantity is present, the factors regulating the rate of decomposition and the nature of the products are of more importance.

Calcium Carbonate.—Like organic matter, this serves other purposes besides providing plant food. It combines with carbonic acid to produce calcium bicarbonate, which by flocculating the clay improves the texture of the soil. It enables plants to withstand the effect of certain injurious substances, *e.g.* magnesium compounds, alkaline salts, &c., that may be present. But its chief use is to furnish a chemical base for certain of the reactions taking place in the soil; so long as it is present the soil remains neutral, in its absence the soil may become acid. The whole character of the natural vegetation, the crop, and the bacterial flora depends on the reaction of the soil; an acid soil is fundamentally different from a neutral one. This is discussed under Calcium Compounds in Soil, to which reference should be made. It will suffice here to recall that on acid soils turnips and cabbage are liable to 'club' or 'finger-and-toe', since the conditions favour the activity of the fungus *Plasmodiophora Brassicæ*; that on the Rothamsted acid grass plots the herbage is altogether different from that on the neutral plots, and that at Woburn barley fails to grow on the acid plot.

An illustration of the influence of calcium carbonate in improving the texture of the soil is afforded by some of the Rothamsted soils.

Geescroft field is really lighter than some of the other soils, and yet always proved less workable, *owing to the smaller amount of calcium carbonate* it contains.

Calcium carbonate occupies an altogether exceptional position among soil constituents in two important respects. It is the only one which can be completely removed from the soil. Soils containing no nitrogen or no phosphorus are unknown, but soils containing no calcium carbonate do occur. Secondly, there is no question of availability with calcium carbonate. If it occurs in more than one form, there is no reason to assume any difference in value.

Reference to Table I shows that fertile soils contain about 0·4 per cent or more. Sandy soils will remain fertile with much less; indeed so long as they retain just enough to prevent the soil being acid they seem to retain their productiveness. Clay soils, on the other hand, require about ·3 per cent; more is useful only as a reserve supply. When too much is present, injurious effects are produced.

The Influence of the Micro-organisms of the Soil on its Fertility.—Hitherto we have regarded the soil simply as a collection of substances having certain chemical and physical properties. But it is not a dead mass: it contains enormous numbers of bacteria and other micro-organisms, the prime function of which is to feed and reproduce themselves. They have substantially the same requirements as plants—food (nitrogen, phosphoric acid, potash, &c.), water, air, &c.—and occur in enormous numbers in soils well adapted to plant growth. Indeed, a fairly satisfactory index of the fertility of the soil may be obtained by counting the number of organisms present, and a still better one by measuring the amount of oxygen they use up (see art. OXIDATION IN SOILS). The organisms must be regarded primarily as competing with plants for food, water, and air, and as being injurious to plant growth to the extent to which they succeed in this competition.

Many, if not all, of the organisms bring about chemical changes in the soil, usually on organic matter, to obtain food or energy, or for other purposes not quite understood, and some of these changes are extremely beneficial to the plant, while others are injurious. The beneficial changes include the formation of humus and the production of plant food from useless organic matter. Whether the benefit accruing to the plant from the useful changes compensates for the losses arising from the harmful changes and the competition just referred to, has not yet been proved, since no one has succeeded in sterilizing a soil and showing how the plant gets on in absence of micro-organisms. There is, however, much indirect evidence to show that the plant gains considerably. The amount of decomposition some of the organisms can effect is large out of all proportion to their weight or to the amount of food they consume; moreover, this food is not permanently lost, but is again set free when the organisms disintegrate under the influence of other organisms or of enzymes. It is known also that liming and aeration, which are essential factors in promoting fertility, have the effect of suppressing some of the injurious changes and favouring other beneficial changes.

Since the micro-organisms have no power of movement in the soil, they are only effective when the organic matter is thoroughly distributed, and the best agents for this purpose seem to be earthworms. They pass quantities of plant remains through their bodies, completely disintegrating them and mixing them well with the soil; they also bring about a certain amount of decomposition. The soil organisms are now able to act, and the plant substance is changed into humus, various other nitrogen compounds, and carbonic acid; ammonia is produced, and finally nitrates are formed. Nitrogen fixation also goes on. All these changes are exceedingly useful. At the same time, other apparently injurious changes are going on, resulting in loss of nitrogen; but, as already stated, the beneficial changes seem to preponderate. See also SOILS, REACTIONS TAKING PLACE IN.

IV. INDICATIONS OF FERTILITY AND BARRENNESS (see SOILS).

V. INHERENT FERTILITY AND CONDITION (see SOILS).

SUMMARY.—A fertile soil must supply in a proper degree all the needs of plants—food, water, air, and proper temperature; none of these must be deficient, or it limits the productiveness of the soil. The amount of potential food is shown by the chemical composition of the soil, but the amount actually available for the plant depends mainly, in the case of nitrogen, and partly in the other cases, on the bacterial changes taking place. The water supply is regulated by the position of the soil, its physical composition, and the nature of the subsoil. The temperature and air supply depend on the water content and on the permeability, *i.e.* on the physical composition; temperature is also affected by the position. The ideal soil contains a suitable mixture of coarse and fine particles (the former to keep it permeable and workable, the latter to enable it to retain moisture), resting on a subsoil of somewhat finer texture, and situated on the lower part of a slope, so that it may get a steady flow of water from the higher ground. It contains a sufficient proportion of calcium carbonate (·5 to 1 per cent), of organic matter, and of other plant foods. If the soil is lacking in any of these respects it loses in productiveness. Should the deficiency arise solely from want of plant food, the proper manures can be added, and will be found to exert their full effect. If the physical composition is wrong, improvement is not quite so easy. Excess of coarse material renders the soil too porous and leads to loss of water; too much fine material, on the other hand, makes it impervious, and prevents aeration and proper movement of water; *improvement is effected in both cases* by adding lime, organic matter, and by suitable management. The soil can thus be got into excellent 'condition', but the effect only persists as long as the lime and organic matter last and the management remains good; it is artificial and temporary, and quite distinct from permanent natural fertility. [E. J. R.]

Fertility in Animals. See FECUNDITY AND FERTILITY.

Fertilization in Animals, the intimate and orderly union of spermatozoon and ovum. It is to be distinguished from *insemination*, which is the transference of the seminal matter from the male into the female; indeed it often occurs without any insemination, namely in those cases, *e.g.* most fishes, where the spermatozoa are discharged by the male on or near the ova after these have been discharged by the female. Whether there be insemination or not, whether, as is often said, the fertilization be external or internal, the gist of the process is very uniform in all multicellular animals. The microscopic spermatozoa are so very numerous, usually thousands to one ovum, that if they have been liberated in the vicinity of the ovum or ova there are many chances that fertilization will occur. In most animals the spermatozoa are very actively motile, moving in water or in the secretion of the female genital duct by means of their 'tails' or flagella. It is their nature to swim against a current, as can be readily shown experimentally, and this is obviously important when they are lodged in a duct in which there is a slow down-current. Moreover, within a short radius, they are attracted towards the ova. When one spermatozoon enters an ovum, a sudden change often occurs in the peripheral living matter, so that the surface becomes resistent or non-receptive to other spermatozoa, or so that a little opening (micropyle) in the egg envelope is closed. In most cases only one spermatozoon enters an ovum, but polyspermy or multiple fertilization is common in some animals, *e.g.* insects. When several sperms enter an egg, all degenerate save one (as happens in cases where polyspermy is frequent), or the result is abnormal development or total failure to develop.

The tail, or locomotor part of the spermatozoon, is left at or near the periphery of the ovum, and plays no part in the subsequent process. Of essential importance is the 'head', which consists mainly of nucleus (linin and chromosomes) which unites in an intimate and orderly way with the nucleus of the egg. The minute middle portion of the spermatozoon, which lies between the 'head' and the 'tail', is also of importance, for it contains a minute corpuscle, the 'centrosome', which seems to play a remarkable rôle in the subsequent segmentation of the fertilized ovum.

In all animals that have been carefully studied in this connection, the ripe spermatozoon, that is to say, the fully formed spermatozoon, ready to fertilize an ovum, contains in its nucleus a number of nuclear bodies, which is (with few exceptions) half the number that is characteristic of the body cells of the species in question. In the course of the sperm-making or spermatogenesis there has been a reduction of chromosomes to half the normal number. An analogous process occurs in the history of the ovum; it passes through a period of maturation involving the throwing off of two small cells or polar bodies, and a reduction of the number of chromosomes to one-half the number found in the body cells. In most backboned animals this reduction of the ovum occurs long before fertilization, and the two reduced nuclei (the male and female pro-nuclei as they are called) fuse to form one nucleus (the segmentation nucleus as it is called). This is true of all domestic animals. In many backboneless animals, such as the threadworm of the horse, which has been so much studied in this connection, the polar bodies are not thrown off until the spermatozoon has entered or is entering the ovum, and the two reduced nuclei do not actually fuse until the first division of the ovum has taken place.

In all cases, however, the fertilized ovum has the number of chromosomes that is normal for the species. If there were no reduction there would be doubling of the number of chromosomes at each fertilization. Both in the reduction of the number and in its subsequent restoration there are opportunities for variation — for new permutations and combinations of the vital qualities of which these chromosomes (and the associated linin) are the vehicles.

Whether the male and female nuclei actually fuse or not, the halves of their component chromosomes are distributed with absolute accuracy to each of the two cells into which the ovum divides, and as this process goes on, cell-division after cell-division, it is literally true that the paternal and maternal contributions form warp and woof of the web we call the offspring. In the first division, the centrosome which is introduced by the spermatozoon seems to play an important part, and all the centrosomes in all the future cell-divisions are probably traceable to it.

Experiments have shown that a fragment of an egg (of a sea-urchin) containing no nucleus may be fertilized and may develop into an embryo; experiments have also shown (*e.g.* for a sea-urchin, a sea-worm, a mollusc) that slight *chemical* and *physical alterations* in the sea-water may induce an ovum to develop without fertilization. Thus we are led to see in fertilization, on the one hand, a stimulus to segmentation or a removal of the conditions inhibiting segmentation, and, on the other hand, a mingling of the paternal and maternal inheritances to form a new unity. See DEVELOPMENT, HEREDITY, INSEMINATION, OVUM, PARTHENOGENESIS, SPERMATOZOON. [J. A. T.]

Fertilization of Plants.—Fertilization is a process which occurs in all flowering plants, in all ferns and horsetails, and in all mosses, only in certain fungi and seaweeds, but never in germs (*bacteria*). Since the details of the process vary in the different plant groups, it will be well for clearness to confine attention to the fertilization of the common crops, whether dicotyledonous, as turnips and beans, or monocotyledonous, as wheat and forage grasses. In such cases, and indeed in all cases of fertilization, two things are required: a male element on the one hand, and a female element on the other. The one without the other is impotent; both together can be effective, inasmuch as fertilization consists in the blending of the male element with the female element, and this for the express purpose of producing an embryo plant from the blended product. The embryo in a

turnip seed or in a grain of wheat is made in this way, and every time that an embryo is produced in the seed of a crop plant it has been preceded by the blending together into one of

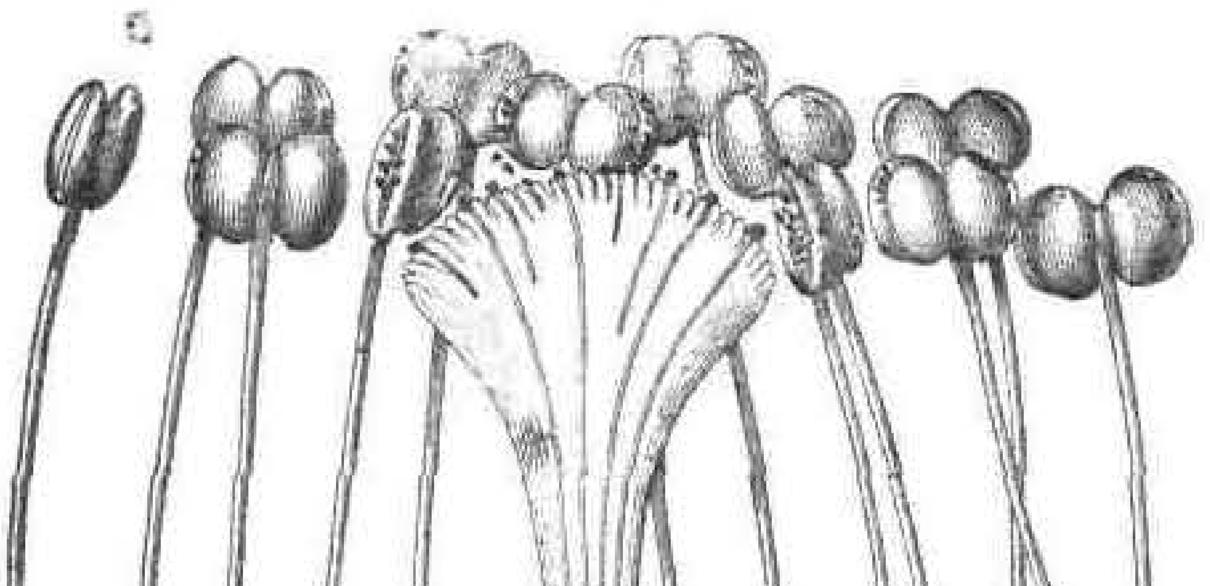


Fig. 1.—Flower of Cistus: Sepals and Petals Removed

The stamens have their anthers in contact with the stigma. The pollen tubes are shown passing down the style and entering the ovules.

the male element and the female element. The male element is always a microscopically minute piece of living matter in which can be distinguished a central denser piece (*nucleus*) surrounded by a more fluid portion (*protoplasm* or *cytoplasm*). The female element is constructed similarly, but it is larger, and it is the thing commonly called egg or *ovum*. In spite of extreme minuteness and apparent simplicity when submitted to microscopic examination, each of these sexual elements, male and female alike, is a true *multum in parvo* which has potentially within it all the characters essential for maintaining the species and the variety of the species, as we see when the resulting embryo unfolds itself and discloses its character in the adult plant. Besides, certain of the sexual elements carry characters derived from ancestors dating many generations back, and not displayed by their immediate parents, but, though not displayed, lying hidden in the background. Such hidden characters sometimes come out in what we call 'sports', 'reversions', 'rogues', and so forth (see Atavism and Mendelism in Plants). Accordingly, if we would keep the progeny true to kind we must weed out the 'sports', 'reversions', and 'rogues', and use as parents for the sexual elements only those individuals which suit our purposes and show no tendency to sport. This process of selection which weeds out the sportive individuals, is called *fixing* the breed.

To understand the fertilizing process in our crops it is well to begin by settling exactly where the male and female elements respectively lie in the plant. The female element is completely enclosed and stationary in a special eggholder called *ovule*, and for every ovule there is but one egg, except in the case of a few plants which are of no agricultural importance. This egg, although often confused with the ovule, is no more the ovule than the jug is the milk; the one is the container, the other the thing contained. We see already that the enclosure of the egg within the ovule is quite complete, so that it is difficult to gain access to an egg; the ovule has to be penetrated before the male element can get into contact with its female counterpart within the ovule. Difficulty of access is increased by further enclosure of the ovule in a special case called pistil (*gynæceum*). If, for example, we examine a bean flower before the fruit forms, we see a young pod completely shutting in a row of small white bodies attached to the upper edge of the pod. The pod is the pistil, and each of the white bodies is an ovule containing the microscopic egg within.

Considering now the position of the male element, we find it enclosed in a special carrying tube which grows out from a pollen grain. The name of this carrier is *pollen tube*. Just as a seed can germinate and produce a seedling plant only under certain conditions, so a pollen grain can germinate and produce its pollen tube only under certain other conditions. One condition necessary for pollen germination is an external supply of moisture and sugar or sugar equivalent, whereas for seed germination no external supply of sugar or organic foodstuff of any kind is required. For example, if we wish to study the pollen tube and male element of a bean plant, we so arrange matters that the

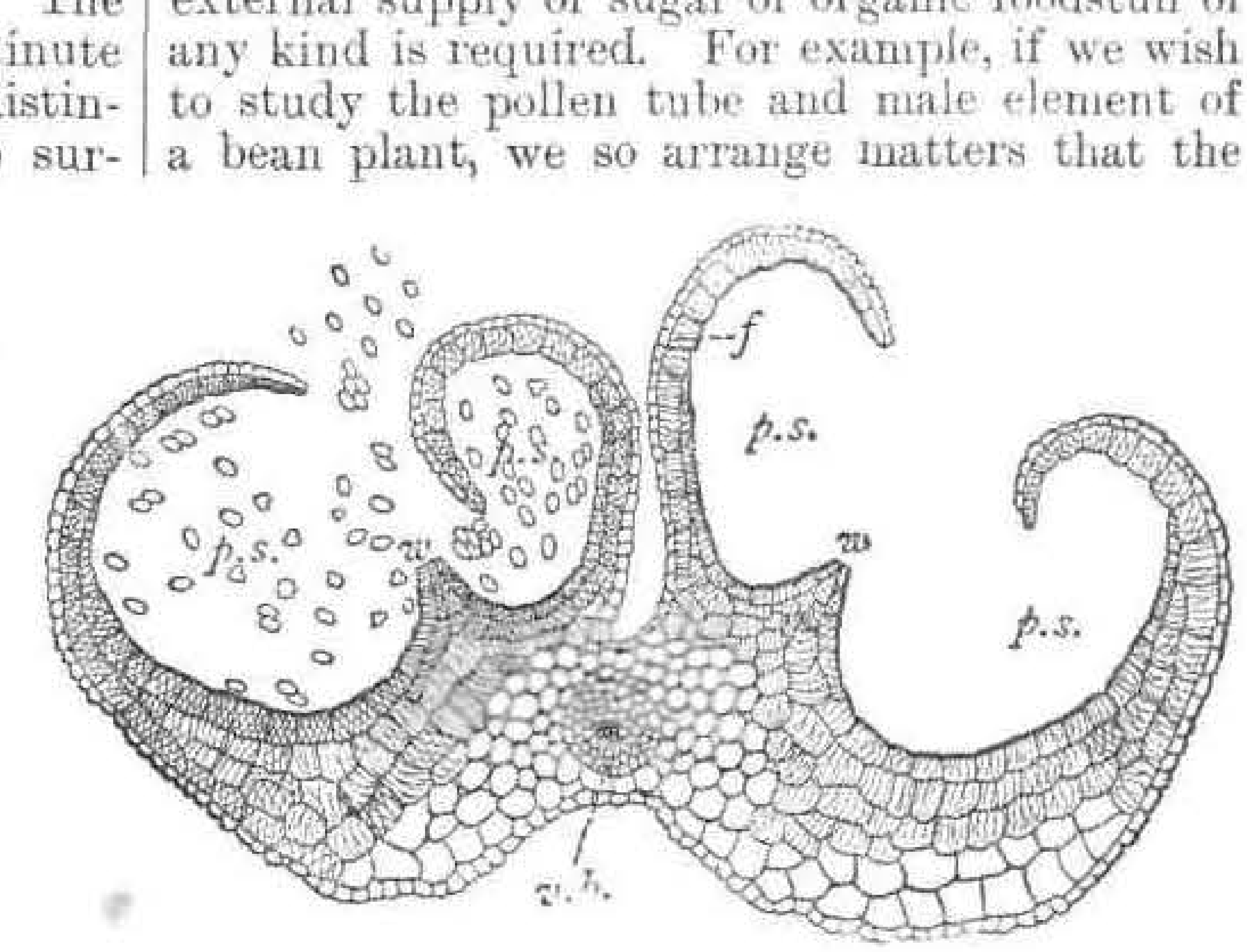


Fig. 2.—Transverse Section of Anther Magnified

p.s., Pollen sac now opened to allow pollen grains to escape.

pollen grains germinate artificially in a warm 5-per-cent sugar solution. In this solution we sow ripe pollen grains taken from the bean anthers, and, after a few hours, microscopic

examination shows that the pollen grains have germinated; the pollen tube has grown out, and the male element is seen lying inside the tube. There are, of course, other things in the tube besides the male element, but with these we have here no concern. The natural bed for the germinating of pollen grains is that specialized part of the pistil which bears the special name *stigma*. Every one of our crop plants has this pollen germinator, which becomes swollen, moist, and sticky when it is receptive and ready to receive the pollen for germination. The stigma is very visible on a large lily flower—it is the swollen end of the central pistil. On a grass, too, say wheat or oats in flower, we often notice a pair of little white feathers projecting between the open valves of the husk. These again are the two feather-like stigmas of the grass pistil for the purpose of germinating the pollen.

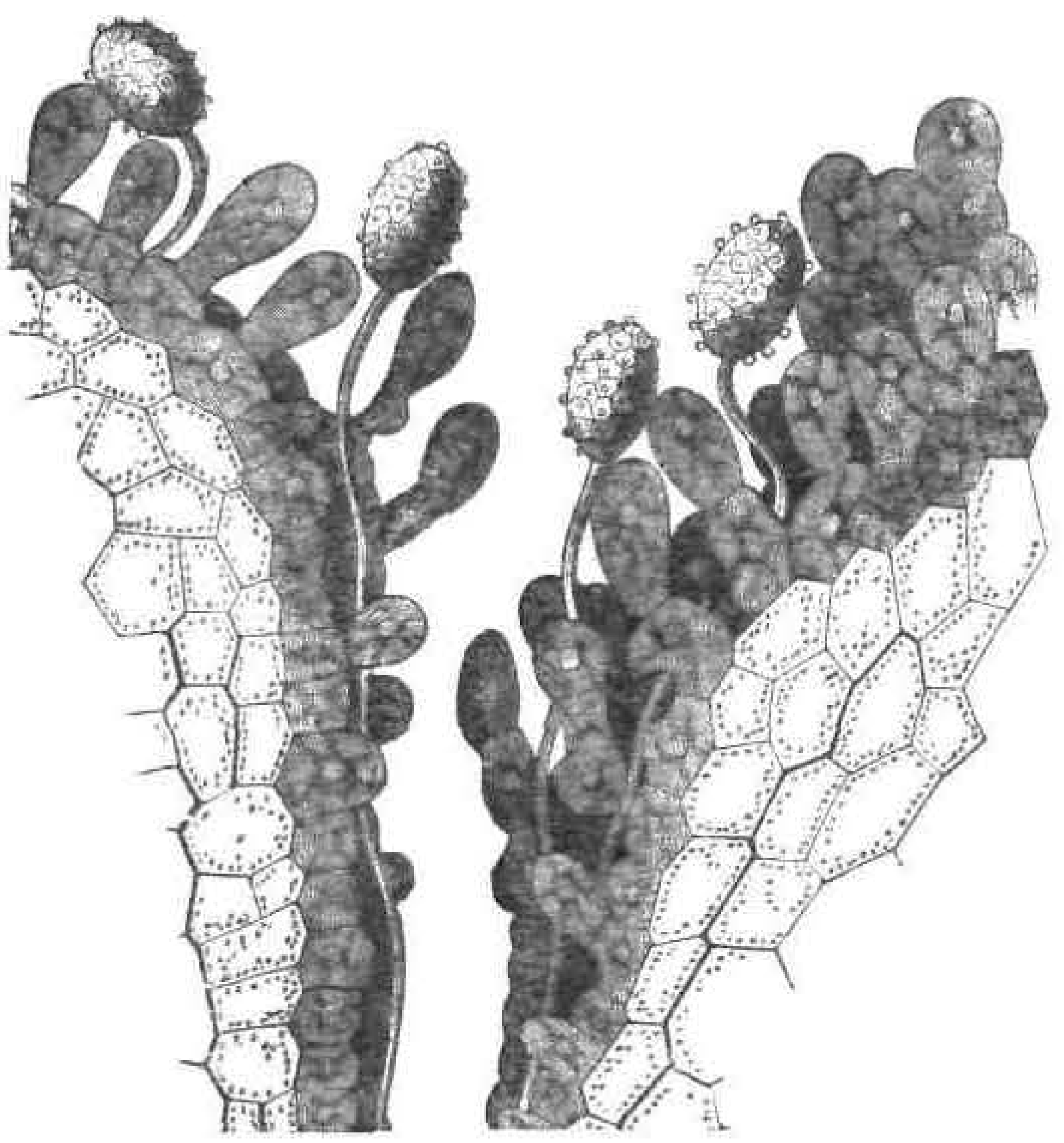


Fig. 3.—Section of Style of Lilium Martagon, showing the sticky pollen grains on the stigma, and sending their tubes down the style—highly magnified.

Knowing the position of the male element and of the female, we have now to consider certain preliminary conditions which must be fulfilled if the male element is to find its egg. We first notice that the pollen grains lie imprisoned within the anther case. This anther case is a barrier to be removed, and accordingly the closed anther opens up by two longitudinal slits; in this way the pollen is got ready for transfer to its germinating bed, the stigma. But this opening of the anther depends upon dryness, and drying up of its component tissues, so that if the weather conditions are such that the anther cannot get dry and split open, it is absurd to expect fertilization and its consequents, namely seed and fruit formation. Many failures of fruit and grain crops are now easily understood—the weather was wet, the anthers did not open, and the pollen lay in its anther case utterly impotent. If the weather is not continuously wet, interference with fertilization by rain depends on the ripeness of the pollen when the rain comes. Take, for example, an early and a late variety of oat growing side by side, and suppose the rain comes when the early variety has its pollen ripe and ready for sowing. From the early variety the resultant crop will be defective, for the rain kept the pollen imprisoned and impotent; whereas the late variety, with its pollen ready when the weather is dry, yields a full crop—under such circumstances the anthers open and allow the pollen free play.

Since pollen has no power of spontaneous motion, a carrier of some kind is required to transfer the grains from the open anther to the stigma. Without such transfer there can be no fertilization and no subsequent grain or seed formation. The nature of the agent concerned in pollen transfer rises into prominence when we are dealing with grain and seed crops, for here the crop value depends upon the successful transfer of pollen to each and every stigma by an agent reliable always, and not fickle like the wind and the roving insect. Such a reliable agent is the stamen itself; at the right moment, when the anther is ready to open and the stigma receptive, the stamen bends over and sows the pollen on the stigma. This is the plan adopted as a rule by grain crops and by beans. If we shell oats, for example, we find quite often the withered anthers adhering to the top of the grain; the husk had never opened, the anthers had never come out, and the stamen evidently had itself applied its own pollen to its own stigma. Within other oat husks we find the grain, but the anthers have gone; here the husk had opened, and the wind had blown away the dry grains of pollen, doubtless transferring some of it to other plants, and in such a case the wind is another agent for pollen transfer. The important point is, that the oat has two strings to its bow, and can use as agents for pollen transfer either its own stamen or the wind. Again, if beans are covered over by fine netting so that insects are excluded, that does not prevent seed formation, and so we are forced to conclude that, as in the oat, the stamen has successfully applied its own pollen to its own stigma. In the case of the bean, the wind as an agent of transfer is out of the question, for the pollen is quite sticky, and so the wind cannot possibly blow it away. The bean, however, like the oat, has a second mode of transferring its sticky pollen, for insects visit the flower in search of honey and carry away pollen sticking to their bodies. When visiting another bean flower it is easy to understand how the pollen becomes transferred from the body of the insect to the stigma of the pistil. We thus learn that the crops of the farm use three agents for transferring pollen—(1) the stamen itself; (2) the wind; (3) the insect. When the plant happens to use the wind or the insect as a carrier, it is quite clear that the pollen of one plant may be transferred to the stigma of another. In such cases the name *cross-pollination* is used, but when the stamen applies its own pollen to its own

stigma the appropriate name is *self-pollination*. Self-pollination tends to yield plants true to kind, for extraneous characters are kept out by keeping out extraneous pollen. *Cross-pollination*, on the other hand, tends to produce mixed breeds by incorporating new characters introduced with the extraneous pollen. Not only new characters are introduced in this way, but hidden features derived from forgotten ancestors are allowed to come to the front and display themselves. In a word, the progeny of the cross 'sport' and vary, thus placing in our hands new combinations from which to select and fix suitable subjects for cultivation. As examples of the almost infinite variety which results from indiscriminate crossing, the various species of willows and brambles may be mentioned.

It is now easy to understand the process of fertilization as carried on by our crops: (1) The anther opens. (2) The pollen is transferred from the anther to the stigma. (3) The pollen grain germinates on the stigma. (4) The pollen tube grows down within the pistil and penetrates the ovule. (5) The end of the pollen tube softens, and the male element passes out. (6) The male element comes into contact with the female element. (7) The two elements blend together into one body called the *fertilized egg*.

The process of fertilization is now accomplished, and the result is a fertilized egg. Other changes now begin—the ornamental parts of the flower fade and fall away, and the pistil ripens into a fruit within which the ovule becomes the seed, containing an embryo plant which is the fertilized egg further developed.

[A. N. M'A.]

Fertilizer. — According to Act of Parliament a 'fertilizer means any article sold for use as a fertilizer of the soil which has been subjected to any artificial process in the United Kingdom or imported from abroad'. This refers only to what is known as artificial manures. The term 'fertilizer', however, is a very general one, and is used to designate any material containing ingredients of manurial value added to the soil to increase its productive capacity. See Artificial Manures, Manures and Manuring, also next article.

Fertilizers and Feeding Stuffs Act. —The law respecting agricultural fertilizers and feeding stuffs is now regulated by a recent Act of Parliament (6 Ed. VII, c. 27) called 'The Fertilizers and Feeding Stuffs Act, 1906', which was passed with the view of protecting agriculturists against frauds in connection with the sale of those articles, the previously existing law not having been found sufficiently strong for the purpose.

Invoices and Warranties.—Section 1 of this Act makes it obligatory in every person selling for use as a fertilizer of the soil any article which has been subjected to any artificial process in the United Kingdom, or which has been imported from abroad, to give to the purchaser an invoice stating the name of the article and the respective percentages (if any) of nitrogen, soluble phosphates, insoluble phosphates, and potash contained in the article. This invoice will have effect as a warranty by the seller that the actual percentages do not differ from those stated beyond the 'prescribed' limits of error (subsec. 1). The terms 'insoluble' and 'soluble' are defined to mean soluble and insoluble in water, or, if so specified in the invoice, in a solution of citric acid or other solvent of the 'prescribed' strength, and percentage of soluble phosphates and percentage of insoluble phosphates are defined to mean respectively the percentage of tribasic phosphate of lime which has been and that which has not been rendered soluble (section 10). Section 1, subsec. 2 similarly makes it obligatory on every person selling for use as food for cattle (*i.e.* bulls, cows, oxen, heifers, calves, sheep, goats, swine, and horses) or poultry any artificially prepared article to give to the purchaser an invoice stating the name of the article and whether it has been prepared from one substance or seed or from more than one substance or seed, and in the case of any article artificially prepared otherwise than being mixed, broken, ground, or chopped, the respective percentages (if any) of oil and albuminoids contained in the article. This invoice will have effect as a warranty by the seller as to the parts so stated, except that as respects percentages the invoice takes effect as a warranty only that the actual percentages do not differ from those stated in the invoice beyond the 'prescribed' limits of error.

If any article sold for use as food for cattle or poultry is sold under a name or description implying that it is prepared from any particular substance or substances, or is the product of any particular seed or seeds, without indication that it is mixed or compounded with any other substances or seeds, a warranty by the seller is implied that it is pure, *i.e.* prepared from that substance or those substances only, or a product of that seed or those seeds only (section 1, subsec. 3). On the sale of any article for use as food for cattle or poultry, a warranty by the seller is implied that the article is suitable to be used as such (subsec. 4). A statement by a seller of the percentages of the chemical and other ingredients contained in any article sold for use as a fertilizer of the soil, or of the nutritive and other ingredients contained in any article sold for use as food for cattle and poultry, in an invoice of the article or in any descriptive circular or advertisement will have effect as a warranty (subsec. 5). But if the article sold for use as a fertilizer or as food consists of two or more ingredients mixed at the request of the customer, it is a sufficient compliance with the provisions as to percentages if the invoice contains a statement of percentages with respect to the several ingredients before mixture, and a statement that they have been mixed at the purchaser's request (subsec. 6).

Analysis of Samples. — By section 2, the Board of Agriculture and Fisheries is bound to appoint a chief agricultural analyst, and every county council is bound to, and the council of any county borough may appoint an official agricultural analyst and one or more official samplers, and a person whilst holding the office of agricultural analyst may not engage or be interested in any trade, manufacture, or busi-

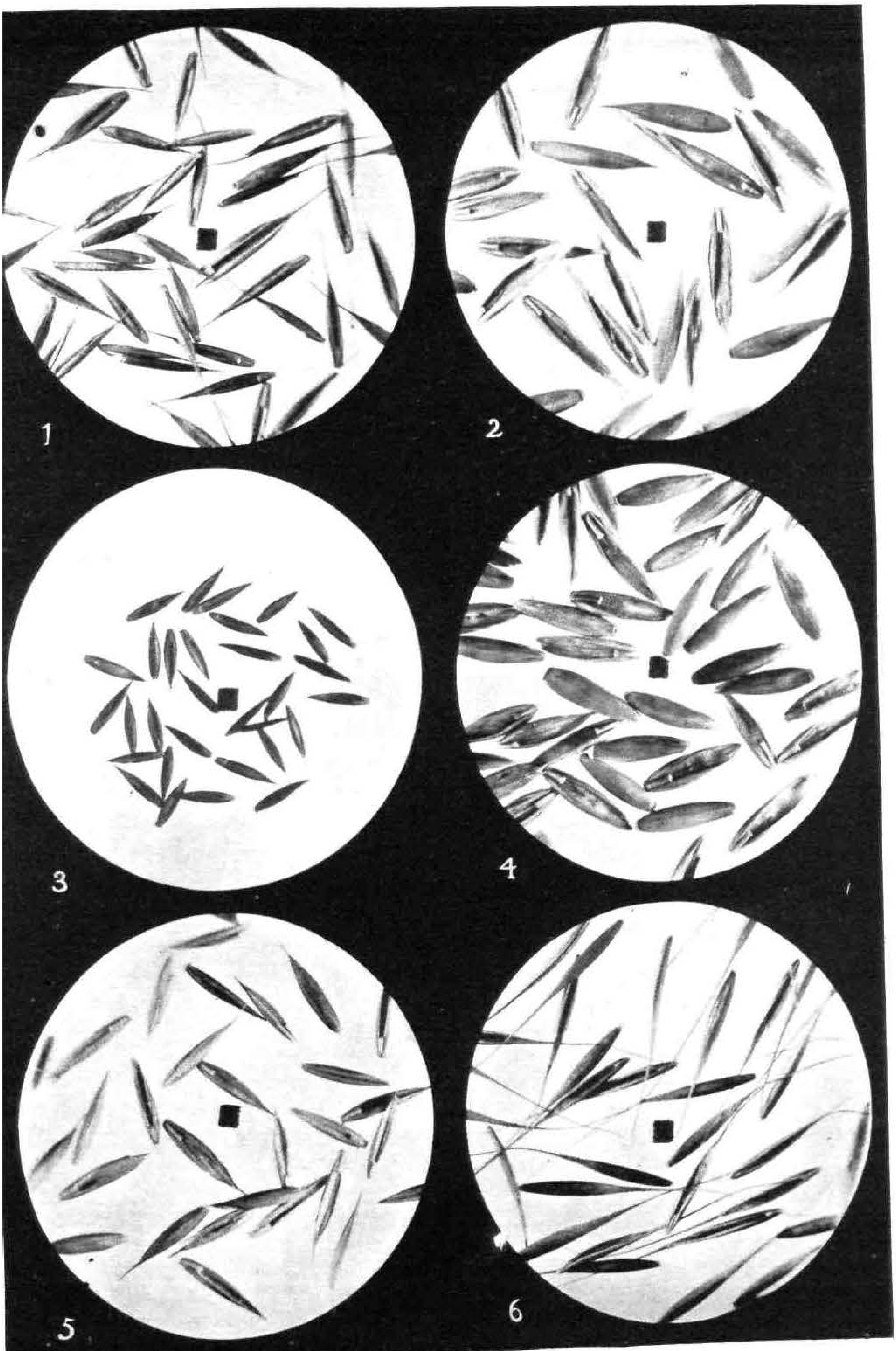
ness connected with the sale or importation of fertilizers or foods for cattle or poultry. By section 3, any purchaser of any article used for fertilizing the soil or as food for cattle or poultry who has taken a sample thereof within ten days after delivery of the article to him or receipt of the invoice, whichever is later, is entitled on payment of the required fees to have the sample analysed by the agricultural analyst of his county or county borough (subsec. 1). An official sampler is bound at the request of the purchaser, and on payment by him of the required fee, to take, and he may without any request take, a sample for analysis by the agricultural analyst of any such article as aforesaid which has been sold or is exposed or kept for sale; but when the article has been sold the sample must be taken before the expiration of ten days after the delivery of the article to the purchaser or receipt of the invoice, whichever is later (subsec. 2). If the sample is taken with a view to any civil or criminal proceeding, the sample must be divided into three parts, each of which must be marked, sealed, and fastened up. Two of the parts must be sent to the agricultural analyst, and one part to the seller (subsec. 3). If the sample is not divided into parts, the agricultural analyst must send a copy of his analysis to the person who submitted the sample to him. If it has been divided into parts, he must analyse one of the parts and retain the other, and send a certificate of his analysis to the person who submitted the sample for analysis, and when that person is not the purchaser of the article, also to the purchaser, and in every case to the seller, and he must report to the Board of Agriculture and Fisheries the result of any analysis (subsec. 4). At the hearing of any civil or criminal proceeding with respect to any article a sample of which has been analysed in pursuance of this section, the production of a certificate of the agricultural analyst, or if a sample has been submitted to the chief analyst appointed by the Board then of the chief analyst, will be sufficient evidence of the facts therein stated, unless the defendant or person charged requires that the person who made the analysis be called as a witness. But in order that this subsection may apply, the sample must have been taken in the 'prescribed' manner and divided into parts marked, sealed, and fastened up (subsec. 5). On any legal proceeding, either party objecting to the certificate of the agricultural analyst of the county or county borough is on payment of the fee fixed by the Treasury entitled to have the part retained analysed by the chief analyst (subsec. 6).

Penalties.—By section 6, if any person selling an article for use as a fertilizer of the soil or as food for cattle or poultry (*a*) fails without reasonable excuse to give, on or before, or as soon as possible after the delivery of the article, the invoice required by the Act; or (*b*) causes or permits any invoice or description of the article sold to be false in any material particular, to the prejudice of the purchaser; or (*c*) sells for use as food for cattle or poultry any article which contains any article deleterious to cattle or poultry, or to which has been added any ingredient worthless for feeding purposes and not disclosed at the time of sale, he will be liable, without prejudice to any civil liability, on summary conviction, for a first offence to a fine not exceeding £20, and for any subsequent offence to a fine not exceeding £50. The section contains a proviso that a person is not to be convicted under paragraph (*b*) if he proves either (i) that he did not know, and could not with reasonable care have ascertained, that the invoice or description was false; or (ii) that he purchased the article sold with a written warranty or invoice from a person in the United Kingdom, and that that warranty or invoice contained the false statement in question, and that he had no reason to believe at the time when he sold the article that the statement was false, and that he sold the article in the state in which it was when he purchased it. A prosecution under this section is not to be instituted except with the consent of the Board of Agriculture and Fisheries (subsec. 3). Sections 7 and 8 enact penalties for tampering with articles so as to procure that the sample taken does not correctly represent the article, or with the sample when taken, and for obstructing the official sampler. By section 9, prosecutions may be instituted by the person aggrieved, or by the council of a county or borough, or by any body or association authorized by the Board of Agriculture and Fisheries.

Application to Scotland and Ireland.—In the application of the Act to Scotland the expression 'council of any borough' means the town council of a burgh, and the duties and powers of councils of counties and county boroughs are to be performed and be exercisable in a county by the county council, and in a burgh by the town council. In Ireland the Department of Agricultural and Technical Instruction for Ireland is substituted for the Board of Agriculture and Fisheries (section 11).

Regulations of Board of Agriculture and Fisheries.—The Board has issued regulations under the Act prescribing that when in an invoice relating to basic slag or basic superphosphate it is specified that a certain percentage of the phosphate contained in the basic slag or basic superphosphate is soluble in citric acid, this is to be taken to mean that it is capable of being dissolved to the extent of such percentage when 5 grm. of the fertilizer and 500 c.cm. of water, containing 10 grm. of citric acid, are continuously agitated in a flask or bottle of about 1 litre capacity for the period of half an hour at the ordinary temperature. Regulations of the Board also deal with the sampling and analysis of samples of fertilizers and feeding stuffs (see Fertilizers and Feeding Stuffs (Sampling, &c.) Regulations, 1906), and set forth the 'prescribed' limits of error in respect of the statements in the invoice of the percentages of nitrogen, phosphates, and potash contained in the fertilizer, or of oil and albuminoids in the feeding stuff (see Fertilizers and Feeding Stuffs (Limits of Error) Regulations, 1906). [A. J. S.]

Fescue Grasses.—Under this name are included not only some of the most valuable grasses of agriculture, such as Tall Fescue and



1, Festuca duriuscula; 2, Festuca elatior; 3, Festuca ovina; 4, Festuca pratensis; 5, Festuca rubra; 6, Aira caryophyllea (Hair-grass). (The comparative degree of enlargement may be gauged by the size of the small central square = 1 millimetre.)

Meadow Fescue, but also the Annual Hair Fescue or Hair Grass (not Aira but *Festuca sciuroides*) so troublesome among Rye grasses, especially when grown for seed. All the Fescue species have a branched ear (panicle), and the spikelet is always composed of many flowers.

There are certain species of Brome grass which closely resemble the Fescue grasses, but distinction is easy if attention is paid to the sheathing part of the leaf. In a Brome the sheath is split not more than halfway down, whereas in Fescue the sheath is split to its very base.

For agricultural purposes the Fescues may be divided into three sections:—

SECTION I.—*The large and broad-leaved perennial species*, cultivated for hay and pastures on superior soils at low altitudes. These valuable top grasses are: (1) Meadow Fescue (*Festuca pratensis*); (2) Tall Fescue, or New Zealand Tall Fescue (*Festuca arundinacea*); (3) Rhenish Tall Fescue (*Festuca elatior*). These three are separately dealt with below.

All these grasses produce large round shoots —round because their leaves are rolled round one another, and not folded together as in the flat shoots of a Cocksfoot. The underground base of the Fescue shoot contains a characteristic purplish-red juice, which enables us readily to recognize the grass when it is pulled up from a permanent pasture for identification.

SECTION II. — *The bristle-bladed perennial species*, which form valuable sheep pasturage on poor, dry, sandy lands from the seashores up to the highest altitudes. Unlike the large Fescues of the former section, the plants here are very diminutive, with the leaf-blade quite narrow, and doubled up into a cylindrical bristle. This character enables these species to thrive on windy sites, on soils too dry and thin to supply a sufficiency of water for the large broad-bladed grasses.

The sole or bottom grasses belonging to this section include: Hard Fescue (*Festuca duriuscula*); Sheep's Fescue (*Festuca ovina*); Various-leaved Fescue (*Festuca heterophylla*); Red or Creeping Fescue (*Festuca rubra*). Many and varied are the commercial names assigned to these bristle-bladed species.

SECTION III.—In this section is included an annual weed Fescue with bristle leaves. On poor, light, dry soils this Hair Grass, as it is usually called, grows up abundantly among the Rye Grass. Being annual, this is a prolific seedbearer, and when the Rye Grass is threshed the Hair Grass seeds become very noticeable impurities, often contaminating the Rye Grass to no inconsiderable extent, and necessitating special cleaning.

(1) MEADOW FESCUE (*Festuca pratensis*) is a tufted, fibrous-rooted perennial, growing from 2 to 3 ft. high in lowland meadows and pastures, where it is among the earliest of our native grasses to form fresh herbage. The leaves are large and broad like those of Italian Rye Grass. The panicle ear is narrow, and consists of several lateral branches, bearing from three to five erect spikelets each, in addition to one which stands in the axil of every branch. Each spikelet contains an uncertain number of florets, varying from five to ten. The outer pale of each floret is rounded on the back, and ends in a very sharp, short point. Meadow Fescue is one of the most important grasses for low-lying, damp lands. On dry, poor, thin soils the plant becomes quite stunted and useless. It is common throughout Europe and Northern Asia. In Great Britain and Ireland, at altitudes under 600 ft., it is found as a natural grass in pastures and meadows where the soil inclines to be heavy, and its presence indicates a soil well suited for such crops as beans and wheat.

On suitable land, Meadow Fescue is one of the most valuable grasses for permanence, for yielding hay, and first-class pasture relished by all kinds of stock. It is less suitable than Rye grasses for single crops of hay, as its full productive powers are not reached till the third year from sowing. It never forms unsightly tufts of grass, but grows up level and uniform, and remains green all the year round.

Meadow Fescue comes into flower about the end of June, and ripens its seeds about four or five weeks thereafter. Commercial seed is sometimes mixed with Perennial Rye Grass. Although the Fescue and Rye Grass seeds are externally very similar, yet the one seed may be readily distinguished from the other if attention is directed to the stalk on the inner face of the seed. This stalk is a narrow cylinder with a prominent flange at its summit, whereas the stalk of the Rye Grass seed is broad, quite flat, and wants the flange.

On suitable land the seed mixture used may contain 11 lb. of Meadow Fescue seed; this amount would suffice to cover about 20 per cent of the whole acre with Meadow Fescue plants, thus leaving 80 per cent of the acre for the other components of the mixture.

Hybrids of Meadow Fescue. — Hitherto these hybrids have not been turned to agricultural account, but as they are now beginning to come into commerce it may be well to refer briefly to them. There are reputed naturally produced hybrids between Meadow Fescue and Perennial Rye Grass known in botanical works as Spiked Fescue (*Festuca loliacea*, de Cand.), also between Meadow Fescue and Italian Rye Grass, &c. No special agricultural interest attaches to these natural hybrids, but some artificial productions may turn out to be of value. As yet, however, no experiments are to hand from which a judgment regarding these selections may be formed.

(2) NEW ZEALAND TALL FESCUE (*Festuca arundinacea*) is a coarse reedlike grass which thrives on wet, sandy soils. Although very productive and permanent, the herbage is too coarse for stock. Accordingly, this species should not be included in grass mixtures.

(3) RHENISH TALL FESCUE (*Festuca elatior*) is one of the largest species. Like New Zealand Tall Fescue, this grass thrives on the lighter classes of land, and is very productive as well as very lasting. Although the plant is so large the herbage is not coarse, and is readily eaten by stock. The Rhenish Fescue may, in fact, be regarded as a specially luxuriant variety of Meadow Fescue. The seeds are often mixed with those of New Zealand Tall Fescue, and

detection of such admixture is therefore important. The best and easiest distinction is by the colour. New Zealand seed is as light coloured as that of Cocksfoot, whereas Rhenish seed is much darker. Sometimes Meadow Fescue seed is substituted for Rhenish seed. The Meadow Fescue seed is narrower, and the point of the lower valve of the husk is broad, blunt, and very frequently broken. Rhenish seed is distinguished by the narrow point, which is never broken, and which often ends in a short beard or awn. The rate of seeding is the same as for Meadow Fescue.

The bristle-bladed fescues are not of sufficient importance to warrant separate consideration. In connection with the seeds, however, it may be noticed that the commercial distinction between Hard and Sheep's Fescue depends upon the presence of an awn on the former seed, and upon the absence of the awn in the latter. Only on the poorest and thinnest soils should seeds of these small fescues be sown, and never by themselves, but always in mixture with seeds of other plants, such as Kidney Vetch. The reason is this: all these small fescues except the creeping species grow in tufts, and so other plants must be incorporated with them to form a complete sward of herbage.

The amount of pure and germinating seed required to cover a whole acre, as given by Stebler, is:—

Hard Fescue, 19 lb. per acre for a pure sowing; Sheep's Fescue, 19 lb. per acre for a pure sowing; various-leaved fescues, 29¼ lb. per acre for a pure sowing; Red Fescue, 19½ lb. per acre for a pure sowing. [A. N. M'A.]

Festing Penny, a provincialism signifying the earnest or *arles* given to servants when hired at fairs or markets. See EARNEST.

Festuca. See FESCUE GRASSES.

Fetid Rove Beetle. See OCYPUS.

Fetlock.—The lock of hair which depends from the joint above the foot and below the knee is the correct meaning of the word, but custom has long assigned it to the joint itself, which is composed of the metacarpal (or metatarsal) bone, the suffraginis or long pastern, and the sesamoid bones behind. [H. L.]

Feu, Feu Duty.—In Scotland heritable rights are governed by the feudal law, whereby in theory the sovereign was originally the proprietor, or supreme superior, of the whole land in the country. He gave grants of lands to persons known as his vassals, who in turn, unless restrained by express prohibition in their grant, could make grants to others as their vassals, each vassal holding of his immediate superior under condition of making certain specified returns for the right conveyed. In earlier times the prevailing tenure was that known as ward-holding, whereby the return to be made to the superior was military and personal service, to which were added certain incidental rights, known as casualties, which were devised so as to throw the lands temporarily back into the hands of the superior, if the vassal, or his successor, became unable to perform his military duties. This form of holding was abolished by 20 Geo. II, c. 50.

As the country became more settled, the legislature began to encourage the granting of lands for agricultural services, or for an annual return payable in grain, cattle, or money. This is the form of holding known as feu holding, and was at first termed ignoble or base, since war was esteemed the only profession worthy of a freeman, and the cultivation of the soil had for long been relegated to slaves or serfs. The term *feu* expresses the right of property enjoyed by the vassal in such a holding, while the term *feu duty* denotes the annual return to be made by him to his superior. The vassal's right in the feu, except when qualified by the grant, is that of an absolute proprietor of the land with all that pertains to it, such as houses, woods, &c., on the ground, or minerals beneath it. It is, however, usual to stipulate that the superior shall retain the right to the minerals, with power to work them, under such conditions, if any, for safeguarding the vassal against damage as may be agreed upon. The vassal is free to sell, lease, or sub-feu the land; and though it was formerly usual, in the deed constituting the grant, to prohibit sub-infeudation, this is now illegal in all feus granted subsequent to 1st October, 1874.

The feu duty is usually payable in money, and since 1st October, 1874, must be of a fixed amount or quantity. It is not lawful to stipulate for the payment of any casualty except at fixed intervals, and unless the amount of the periodical additional sum be certain. Where the return is in the nature of agricultural or other services, they may be compulsorily commuted by the sheriff. Where the feu duty is payable in grain, &c., the value thereof in money is, where necessary, determined by the fiars' prices (which see). The feu duty is a debt on the lands to the effect of giving the superior a preference over purchasers and creditors of the vassal to the extent of all unpaid feu duties for forty years back; apart from express stipulation in the grant, interest does not run on arrears till a judicial demand for payment has been made. But in lieu of claiming arrears, the superior has the right, when the feu duty is two full years in arrear, to retake the lands free of all sub-feus or other burdens on the feu which he has not recognized. This forfeiture is only established, however, by decree of the court. [D. B.]

Feudal System.—The essential conditions of the feudal system were those of restricted rights in property, as contrasted with the full rights of allodial tenure, combined with vassalage and the rendering of military or civil services to the grantor of the estate in return for the usufruct of the property and the protection which he afforded. When these services were commuted into money payments the feudal system was in course of slow extinction, and the worst conditions of vassalage imposed upon the occupiers of land soon ceased to exist. Feuds or fiefs were occasionally extended to other property than land; but these were only offshoots of the system which need not be further noticed.

Feudalism was usually based upon conquest, national or tribal, in the several countries in which it prevailed, and even when it arose

directly from economic causes, these were generally connected with warfare in the turbulent times in which the system flourished. Some of its characteristics were present in countries in which it was never established as a general system, as in the ancient Roman Empire, for example, and probably they prevailed to some extent in prehistoric times. But as a system, so far as there is any historic record, feudalism was first established by the Teutonic nations when they overthrew the Roman Empire and settled in the conquered countries. That the germs of it had been in existence in Germany long before, there is every reason to suppose; but it was long after the overthrow of the Roman Empire that a general system of feudalism was established in the former country. It was never universal in Germany, in the conquered Roman countries, in France, or in other Continental countries, as it afterwards became in England. For some reasons not clearly understood, free owners of land among the peasantry of all these countries are known to have been in existence side by side with the vassals who enjoyed only the usufruct of the property which they held. The feudalism of France and Germany is usually regarded as the *real* and *typical* feudalism, and that of England as a modification or incomplete development.

Although the feudal system was in existence in Germany long before it was thoroughly established in this country, it lingered on much longer; for it was not until 1807 that villeinage was abolished in Prussia, so far as it affected the personal status of the occupier of land, and it still remained for the law of 1811 to abolish all villein and other feudal tenures, and to establish allodial ownership instead.

As stated in the art. AGRICULTURE, the Saxon invaders of this country introduced the feudal system by means of their conquest over the Britons and their intertribal warfare after they were settled in England, so that even the occupiers of land, who were superior to the serfs by whom the lands of the settlers were tilled, became mere retainers under the dominion of the thanes, and entitled to their protection. The extent to which this change took place has been the subject of much controversy, and it may be that there was some exaggeration in the statement that in the time of Alfred the Great 'every man but the king had his lord'. At any rate it remained for William the Conqueror to develop the feudal tenure in this country universally and systematically, and more thoroughly, indeed, than it had been developed in any other country. He assumed the lordship of the whole of the land, and the great estates which he distributed among his followers were held from him as the superior landlord. Moreover, he exacted from the sub-tenants, as they may be styled, an oath of fealty to himself, in addition to that which they gave to their immediate lords, thus establishing a dual fealty which had not been exacted in any other country.

In addition to rights of service from their tenants, the lords were granted privileges of wardship and powers over the marriage of female wards, also various fines or other money payments, which were often onerous, and sometimes unjustly exacted. The services varied with the grades of the tenants. In the early times of feudalism military service was much the most important. It appears to have been unlimited at one time. That is to say, the tenant was bound to serve in war for as long as his lord required his services. But this exaction became limited after a time, and other duties of the vassals were similarly regulated. Feudalism received a heavy blow when Henry II was driven by the exigencies of warfare to dispense with the inefficient military service provided by the lords who were his vassals, in return for a tax called escuage, enabling him to hire troops. Fiefs were at one time revocable at the pleasure of the lord, and in any case he became repossessed of the land on the death of a tenant; but later on they became legally hereditary, and eventually descent was extended to collateral relations under strict regulations. A fine was due to the lord, however, on each change of tenancy. Alienation without the consent of the lord entitled him to escheat the property. If a female ward refused to accept as a husband the man provided for her by the lord, the latter was entitled to take the money which any other man would pay for the right to marry her, and after the rigour of this intolerable oppression was relaxed the father of the girl had to pay a fine to the lord on her marriage.

The manor was introduced into Great Britain with the feudal system. About one-fourth of the arable land was usually retained by the lord as his demesne and farmed by him, the remainder being distributed among his vassals of various degrees. There are no records of the gradual process by which the serfs became converted into so-called 'free tenants', who were bound, in spite of their 'freedom', to render service in the cultivation of the lord's demesne either personally or by deputy. The services were strictly defined in the court rolls of manors. Some of these rolls dating from the latter part of the 13th century show that the tenants of a manor were then divided into villeins or free tenants, serfs, and cottagers, all occupying land. A good example of the state of affairs existing at the time was given by Professor Rogers in Six Centuries of Work and Wages, in relation to the small manor of Cuxham, in Oxfordshire. The two principal tenants each held the fourth part of a military fee, and were bound to such obligations as tenancy in knight service entailed. If escuage (or scutage) was imposed, each had to pay one-fourth part of the assessment on the entire fee. They made suit in the manor court. The lords of the manor, the Warden and Scholars of Merton College, Oxford, had the guardianship of their heirs while these were under age, and the right of disposing of any female heir in marriage. The Prior of Holy Trinity, Wallingford, held a messuage, a mill, and 6 ac. of land under no other obligation than that of offering prayers for the donors. The rector of the parish held at a nominal rent a small portion of the arable land occupied in common. One of the free tenants had a messuage, with $3\frac{3}{4}$ ac. of land, the portion of his wife, at a

small money rent, and another messuage with 9 ac., for which he paid annually 1 lb. of pepper. His services are not defined. Each of the serfs had a messuage and about 12 ac. of land, his rent being mainly paid in corn and labour, though he paid also a trifle in money annually and whenever he brewed beer. In corn he had to pay 1 qr. of seed wheat at Michaelmas; a peck of wheat, 4 bus. of oats, and three hens on November 12; and a cock, two hens, and twopennyworth of bread at Christmas. His services were those of ploughing, sowing, and tilling ½ ac. of the demesne, and other work when ordered to do it by the bailiff on any days except Sundays and feast days. He had to reap on three days in harvest with one man. He was not entitled to marry a son or daughter, to sell a head of live stock, or to cut down oak or ash trees without the consent of the lords of the manor. Some of the serfs held additional plots of land at labour rents. The cottagers each had to pay a small money rent for a tenement, and to give a few days of work in haymaking and harvesting, in return for which a trifling wage was paid for haymaking, while food was given in harvest. During the rest of the year they were free labourers, earning money on the demesne. On another manor the free tenants held land at a nominal money rent, but were liable to serve in the case of war in Wales for forty days, armed as defined, at their own costs, being maintained at the lords' expense if their services were required longer. The services of the serfs and cottagers on this manor were more onerous than those required at Cuxham, while the money rents were lower.

A serf was not allowed to migrate from a manor without his lord's consent, and in that case he had to pay a small annual tax. If he allowed a daughter to marry without his lord's authority, he had to pay a fine. Other fines were exacted for sending children to schools or allowing them to enter the Church as a profession, the lord's licence being required for each event. These and other degrading conditions of feudalism were gradually relaxed and ultimately abolished. Difficulties from various circumstances affecting the lords were the tenants' opportunities, of which they did not fail to take advantage. The introduction of leases had a great effect, and otherwise money payments steadily superseded services. Serfs became free tenants, and cottagers free labourers. But it was not until the time of Charles II that military tenures and other abuses of the feudal system were abolished by statute, the operation of the law dating from 1645. This law was the result of the great rebellion which led up to the establishment of the Commonwealth, and was practically the deathblow to feudalism. Subsequent legislation further undermined the system; but to this day there are survivals of it in the legal terms used in the conveyance of landed property, and in the feus so common in Scotland. [W. E. B.]

Fever Fly (*Dilophus febrilis*), a fly so called because it was believed to appear in the rooms of fever-stricken patients. This is a small dipterous insect from 2 to 3 lines long, shiny black in appearance, and having whitish-brown wings. The larva is a small whitish, legless grub with a brownish hairy head; the pupa is brown. Two broods are produced in one year. The fever fly has been known to appear in vast swarms in several districts, and though of no great economic importance the larva occasionally does considerable damage in hop gardens by eating away the roots.

Fiars' Prices.—In Scotland the sheriff of each county must before the 1st of March annually fix the standard prices of grain—these prices being what are known as the fiars' prices—in order to determine the rate at which payments stipulated for in grain (such as the stipends of parish ministers) may be converted into currency. [D. B.]

Fibre.—The term 'fibre' may be used to denote the materials which together make up the cell walls or framework of plants, and by which therefore the toughness and fibrous character of the various parts of plants are determined. Owing, however, to the imperfections of the method commonly employed for estimating the proportion of these fibrous materials present in plants, the term 'fibre' or 'crude fibre' is now commonly employed in a more restricted and conventional sense, and refers simply to that portion of the organic matter of plants (or foods) which is not dissolved by treatment under definite conditions with dilute acid and alkali (see art. ANALYSIS).

When this purely conventional method of estimation was first introduced by Henneberg and Stohmann, it was thought to afford a satisfactory means of isolating and estimating the tough framework of plants, which was then regarded as composed simply of cellulose and lignin-like derivatives. The more modern investigations of Schulze, König, Tollens, and others have, however, demonstrated the presence in the cell walls of a great variety of carbohydrates, pentosans, and lignin bodies, some of which are completely soluble, others only partially soluble, and still others quite insoluble in the dilute acid and alkali. What we now term 'crude fibre' is thus a mixture of variable composition, and cannot be held to represent simply the framework of the plant. Thus Schulze (1897) found that crude fibre, as estimated by the above method, formed only 29 per cent of the non-nitrogenous organic ingredients of the cellular tissues of wheat bran, whilst in the case of shelled lupin seeds the proportion was only 6 per cent.

The chief ingredients of the crude fibre are cellulose, pentosans, and lignin-like bodies. In general, cellulose will be the most abundant and most digestible ingredient, although only a portion of the cellulose of the plant (or food) escapes the solvent action of the acid and alkali. The proportion of pentosans in the crude fibre varies considerably, being greatest in the coarse fodders, *e.g.* Tollens (1897) found in the crude fibre of meadow hay 5·2 per cent of pentosans, whilst in the case of rye straw the proportion was as high as 11 per cent.

The proportion of crude fibre in plants varies greatly with the species, conditions of growth,

and age of the plants. The fibre is present in the least proportions and is softest in character in the young and juicy plants and parts of plants, but, owing to the thickening of the cell walls, steadily increases in amount and toughness and becomes less digestible as the plant grows. Thus pasture grass contains less crude fibre than hay, and early cut grass less than that which is allowed to ripen before cutting. The different parts of the plant show characteristic differences in their content of crude fibre. Thus it is usually most abundant in the stem, less so in the leaves, and least of all in the seed (apart from husk) or tuber. In the case of seeds the crude fibre is largely in the outer coatings, and hence is more abundant in those foods (*e.g.* bran, gluten feed) which consist mainly of these coatings than in the meals prepared from the deeper layers of the seed (*e.g.* pollards, gluten meal).

As a rule, large plants are richer in crude fibre than small ones. Thus the dry matter of the wood of trees is very largely composed of crude fibre, whereas in the case of smaller plants the crude fibre will seldom amount to more than one-third of the total dry matter.

With regard to feedingstuffs in general, we may say that hays, straws, and grain foods rich in husk are relatively rich in crude fibre, whilst tubers, roots, and grain foods poor in husk contain only small amounts.

With regard to the feeding value for productive purposes of crude fibre opinion has varied greatly, some writers being inclined to credit it with fully half the value of the easily digested carbohydrates (starch, &c.) when fed to animals capable of dealing with it (oxen, sheep, goats). Others have declared it to be valueless. The recent experiments of Kellner and others have demonstrated that the truth lies between these two extremes, and that the nutritive value of the fibre is greatly affected by its mechanical condition. Thus Kellner found the nutritive value of straw to be appreciably increased by fine grinding, and to be more than doubled when the straw was reduced to a pulp. In the latter condition the digested fibre was indeed fully as effective as starch. For further information see arts. FATTENING, NUTRITION OF ANIMALS. Commercially the term fibre is applied to such fibrous substances as are employed in manufactures. See next article. [C. C.]

Fibres and Fibre-producing Plants. — The vegetable fibrous materials may be grouped as follows:—

1. Dicotyledonous bast fibres, which may be referred to two sections: (*a*) Higher textiles, such as flax (linen), rhea (ramie, or China grass), Rajmahal hemp, &c. &c.; (*b*) lower textiles, such as hemp, jute, lime-bast, Sida, sun-hemp, Deccan-hemp, &c. &c.

2. Dicotyledonous flosses or seed hairs, which may also be spoken of under two sections: (*a*) Higher textiles, cotton, and (*b*) lower, the silk-cottons, kapok, &c., which are mainly utilized in upholstery.

3. Monocotyledonous (fibro-vascular) fibres derived from stems, leaves, or fruits. These for the most part are worked up in what may perhaps be spoken of as the industrial rather than textile industries—such, for example, as in the production of cordage and rope, brush and wicker work, matting, &c. The chief fibres known to European commerce under this assemblage are (in alphabetical sequence of their trade names): Aloe (Agave) or Sisal-hemp (Henequen), Bahia piassava, various bamboos and reeds, bass (of Madagascar and West Africa), bowstring-hemp (including Neyanda), coir, ejow or gommuta, grass-matting sedges, kittul, Manila-hemp, Mauritius-hemp, Mexican-fibre (Istle brush fibre and whisk fibre), munj, New Zealand flax, Palmyra, Panama, Para piassava, pineapple, rattan and other canes, screw pine, &c. &c.

4. Lastly, the waste materials in working up these, as also old textiles, &c., of any of the fibres above mentioned, as also a few special fibrous materials, such as esparto (halfa) and bhabar grasses, wood and bamboo pulp, and a limited number of fibres demanded for special purposes, such as daphne and paper mulberry, are in demand as paper-making materials. As a rule the paper-maker cannot pay for a specially cultivated supply, hence only the cheapest and most economical materials can be accepted as suitable for paper-making.

It is thus certainly peculiar that all the higher-class bast and floss fibres are derived from dicotyledonous plants, and moreover that these should belong to such a very limited number of natural orders. The Malvaceæ, Tiliaceæ, and Lineæ, three closely allied families, afford three of the most important of fibres—cotton, jute, and flax; while rhea and hemp belong to the Urticaceæ, and sun-hemp to the Leguminosæ. It is perhaps but natural that modern commerce should have concentrated attention on but few out of the many dicotyledonous fibres known to exist, since each additional fibre would almost of necessity involve special machinery. If the requirements and fashions of the world could be met by new patterns and fresh tinctorial effects, there was nothing to be gained by complexity of materials. The little progress attained with rhea and Rajmahal hemp is in fact best accounted for by this circumstance, since, in point of intrinsic merits, few fibres are their equals. With the exception of pineapple, none of the long list of monocotyledonous fibres (above enumerated) can be said to be worked up into fine textiles, though many are woven into mats or plaited into wickerwork and hats, often of extreme delicacy and intricacy. The multiplicity of the forms and properties of these fibres is, moreover, but an expression of the diversity of the purposes and uses which they serve. [G. W.]

Ficus, the genus of plants to which the common Fig belongs. See FIG TREE.

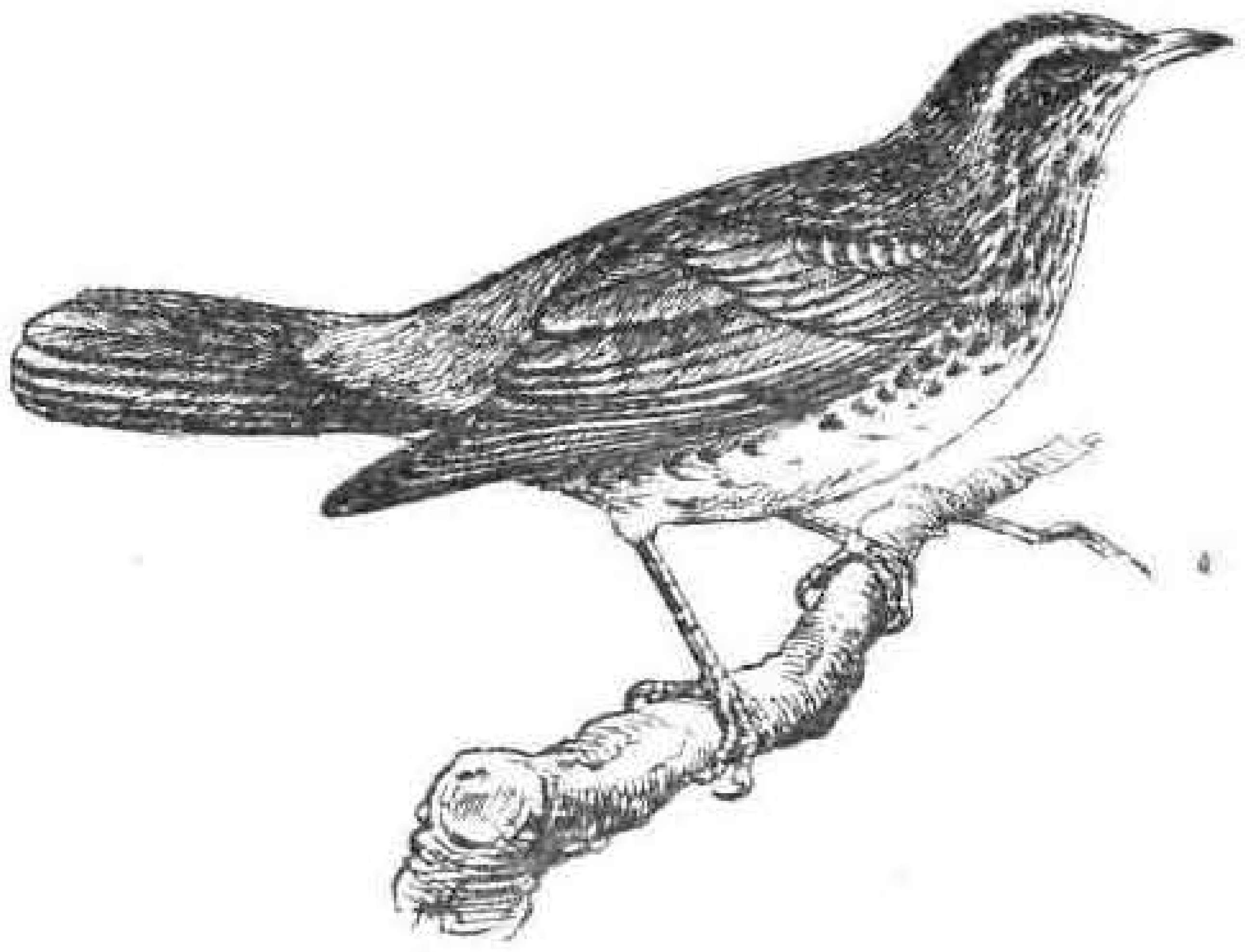
Field.—Although not necessarily meaning a confined space, the word is generally understood in this sense, in its application to farms. On arable farms, fields need not be divided by fences, and commonly exist as definite areas devoted to separate crops. On most old-cultivated land, especially where arable and pasture are intermixed, the fields are fenced, and are

often of small size. The waste due to small fields and wide fences has been estimated at 5 per cent of the entire cultivated land of England. (See FENCES.) This evil is to a great extent localized, and on the open wolds and downlands, fields are often 50 ac. in extent. In enclosed, and especially in stiff-land districts, they are too often from 3 to 4 ac. and even less in extent; but so far as economy is concerned, no field should be less than 10 in area. The principal objections to small fields are that they render every tillage operation more expensive; that they multiply fences and gates; that they are an obstacle to steam cultivation; that they provide harbour for vermin of all kinds, including insects and weeds, and that they hinder the drying of hay and corn at harvest. With respect to the first point, the late Mr. J. E. Ransome, of Ipswich, showed that it takes—

8 hr. 44 min. to plough 1 ac. in a field 100 yd. long.
7 hr. 6 min. to plough 1 ac. in a field 200 yd. long.
6 hr. 34 min. to plough 1 ac. in a field 300 yd. long.

The same ratios would hold good in harrowing, rolling, drilling, so that the loss of time is perennially repeated. A field 100 yd. square contains just over 2 ac., and one 200 yd. square, 8¼ ac. The grubbing of superfluous fences and the throwing of small fields together is one of the first improvements which should be effected on estates in which small fields predominate. The precise form and shape cannot be controlled, but 15 and 20 ac. are reasonable sizes on farms of 400 to 500 ac., and 10 ac. is not too large a size on smaller farms. There is no advantage in small fields, but they are often rendered necessary by the proximity of pasture land or boundaries. A few small fields, garths, or paddocks are convenient near the buildings for calves, mares and foals, and other uses; but large fields of square or rectangular shape are more convenient for arable cultivation. What are called 'butts' (short work) in ploughing, rendered necessary by long corners and bulging hedgerows, are a perpetual nuisance, which cannot always be abated, on account of permanent watercourses, boundaries, and adjoining pasture fields. When contiguous arable fields are divided by a crooked hedge the evil is doubled, and no time should be lost in abolishing the offence. The land thus recovered will often be found to be 6 or 7 yd. wide, and is always much more fertile than the soil on either side owing to its being fresh. The bank is also beneficial if spread over the surface adjoining, so that the expense of removal is met by a permanent improvement. [J. WR.]

Fieldfare (*Turdus pilaris*).—This bird is the second largest of the thrushes, being about 10¼ in. long. Its conspicuous white breast and association into flocks make it easily recognizable. The Fieldfare does not nest in Britain, but mostly breeds in Siberia and north-east Europe, sporadically also in Germany and Holland. In Britain it usually arrives from the north in early October, and remains until late March or early April. The food essentially consists of insects, snails, and worms, to which juicy berries (*e.g.* juniper and mountain ash) and sometimes a small amount of grain are



Fieldfare (*Turdus pilaris*)

added. The species must be regarded as highly beneficial to agriculture. [J. R. A. D.]

Field Mouse.—The true Field Mouse (*Mus sylvaticus*), or Long-tailed Field Mouse as it is commonly called, is sandy brown in colour, with a white under surface. The body is about 4 in. long, and the tail, which is hairless, is nearly the same length. It is easily distinguished from the Field Vole (see next art.) by its long pointed muzzle and the longer, erect, and naked ears. See also MOUSE.

Field Vole.—The Field Vole (*Microtus agrestis*) is a pest on the farm. It lives on roots, tender bark of trees, grass, &c., and is very prolific, producing as many as four litters in the year. It is sometimes called Short-tailed Field Mouse, and is easily distinguished from the Field Mouse proper by its short hairy tail, the short, round muzzle, and the small, almost hidden ears. See also ARVICOLINÆ and VOLES.

Fife Horned Cattle, a breed of large black cattle, now extinct, analogous to the black dairy breed of Holland. It is said that they were used in crossing with the Aberdeenshire cattle, the progenitors of the Aberdeen-Angus.

Fighting Sheep. See HUNIA.

Fig Tree (*Ficus Carica*), nat. ord. Urticaceæ, is a native of western Asia (Asia Minor), and possibly also of northern Africa and even of southern Europe. It is a deciduous tree that attains a height of from 20 to 30 ft. It got the names Ficus and Fig very possibly from the Hebrew *feg*, and the name Carica from Caria, a locality famed for the quality of its figs. The so-called 'fruit' is a cavernous fruit-stalk, which has an opening on the top and bears within numerous very small flowers that in time mature into minute fruits, commonly called seeds. When ripe it becomes turbinate, or even elongated pyriform in shape, is succulent and fleshy in texture, and when fully mature usually darkens to a purple tint. Fertilization is accomplished by insects, which pass within and carry the pollen from the male to the female florets. From classic times it has been the practice to place the fruits of the wild or caprifig within the boughs of the cultivated plant, in order to aid in fertilization, and this was in consequence

spoken of as caprification. The cynips insects, that usually infest the wild figs, leave the withering fruits and enter those of the cultivated plant, thereby hastening maturity. It was believed, in fact, for centuries that the process in question assisted the setting of the fruit, and thereby

Fig (*Ficus Carica*)

largely prevented the shedding of unripe fruits, often a serious matter in fig cultivation. It is now very generally accepted that adventitious fertilization injures the quality of the fruit, while it does not in any way check the shedding of unripe figs. The true explanation of the shedding is the deficiency of moisture that often prevails during the early stage of fruit formation. The injury is done then, though not rendered visible until the subsequent rain once more starts the plant into vigorous growth, the first manifestation of which is the throwing off of now useless fruits. To preserve the crop, therefore, irrigation must be resorted to whenever the natural moisture fails.

The trees are propagated by cuttings of one-year-old wood, planted in beds during early spring. A rich mouldy soil with underlying limestone and free drainage is essential. The permanent plants are grown 10 to 12 ft. apart, and, as the branches require support, figs are best raised against a wall. In the south of England, however, standard figs are often grown in the open air. But they are liable to be killed by severe frost, though they not infrequently spring again from the roots. They begin to bear in the second or third year, and continue thereafter to give crops for 15 to 20 years. They may, however, live to a greater age, certain historic plants being known to be 350 years old.

There are two fruiting seasons, June to July, and again in January. The second is by far the more important, and many growers do not allow the first crop to mature, in order to strengthen the second. Figs that are intended to be preserved are cut from the trees and placed on trays or shallow boxes and exposed to the sun, much after the method that grapes are dried into raisins. But in order to soften the skin they are sometimes submitted, as a first stage of treatment, to the fumes of burning sulphur, or are dipped into a hot solution of common salt or of saltpetre. The sulphur process, however, injures the flavour of the fruit, and is now very generally condemned. The figs are turned over twice daily to secure uniformity in drying, and during this process a quantity of their contained grape-sugar escapes to the surface and crystallizes, hence the fruits become literally preserved in their own sugar. If favourable weather prevails, the figs may be dried and cured within a week's time. They are then carefully assorted and firmly compressed, then packed in boxes. The imports of figs and fig cake for the past five years, taken by Great Britain, have averaged 184,000 cwt., valued at £240,000, three-fourths of which came from Turkey in Asia. [G. W.]

Figure-of-8 Moth, so called because of the white mark in the shape of the figure 8 which is present on the brown fore wings. See DILOBA.

Figwort, or **Knotted Figwort** (*Scrophularia nodosa*), is a bald perennial herb of moist

Figwort (*Scrophularia nodosa*)

1, Corolla opened. 2, Calyx. 3, Fruit (capsule).

land, occurring as a weed in fields, on waste land, and by the hedgeside. The plant belongs to the same nat. ord. as the Common Foxglove, namely

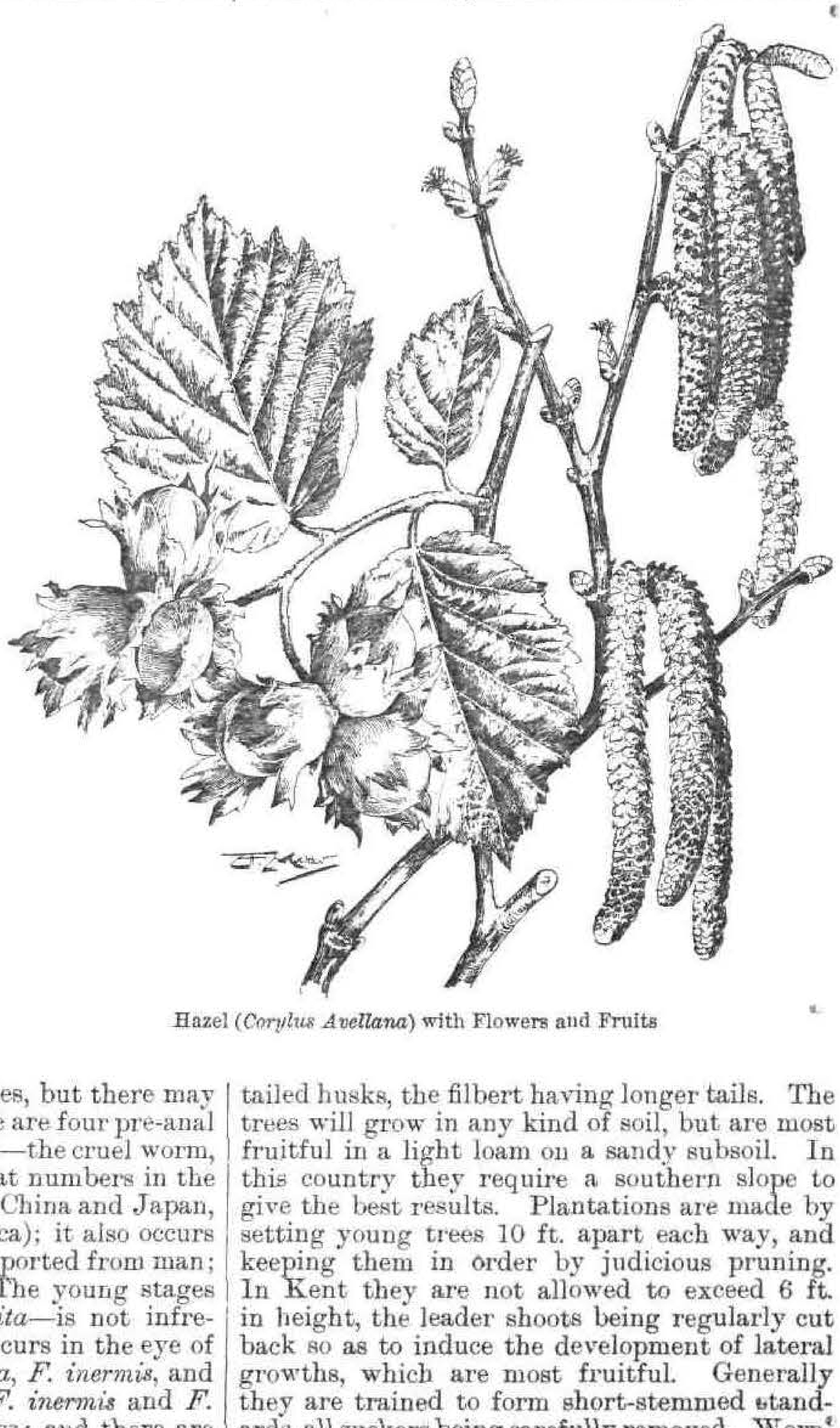
Scrophulariaceæ. The underground portion of the stem is specially enlarged, and takes the form of a fig-shaped tuber, which bears lateral tubers as its branches. The soil is exploited by the roots which spring from these tuberous stems. The aerial portion of the stem is simple, and of square section; on poor lands it rises to a height of about 1 ft., but to 3 ft. or more on moist, rich soils. The leaves are opposite, with large blades 2 to 4 in. long, shaped like a heart, with a sharp point and sawlike margin. The largest leaves are near the ground, but as we ascend the size gradually diminishes, till in the neighbourhood of the floral region, narrow linear bodies are all that represent the leaves.

In summer, loose clusters (*cymes*) of flowers form in the angles of the narrow upper leaves. The corolla is a small ($\frac{1}{3}$ in.) greenish-purple globe, with a characteristic little scale (*staminode*) on the inside of the upper lip. The fruit is composed of a dry seedcase, which opens to let out the numerous small brown seeds with wrinkled skins.

When this weed occurs it should be pulled out, and care should be taken that the whole of the underground tuberous portion is removed. (See WEEDS, ERADICATION OF.) A lotion made from the underground stem of Figwort is sometimes used to cure scab in swine. [A. N. M'A.]

Filaria, a large genus of threadworms or Nematodes, parasitic in backboned animals, especially within serous cavities and in the connective tissue beneath the skin. The members of the genus are usually very thin threads; the males are in most cases smaller than the females, and have the posterior part of the body curved or coiled; there are usually two unequal spicules, but there may be only one; in most cases there are four pre-anal papillæ. A well-known species—the cruel worm, *Filaria immitis*—occurs in great numbers in the heart of the dog (especially in China and Japan, but also in Europe and America); it also occurs in wolf and fox, and has been reported from man; its life-history is unknown. The young stages of another species—*F. recondita*—is not infrequent in the dog; *F. equina* occurs in the eye of horses and cattle, just as *F. loa*, *F. inermis*, and *F. oculi humani* do in man; *F. inermis* and *F. papillosa* occur in horse and ass; and there are many more. Of great importance is the guinea-worm, *F. (Dracunculus) medinensis*, a formidable subcutaneous parasite of man, which passes part of its life-history in one of the small crustaceans (Cyclops) popularly called water-fleas, and along with this must be mentioned the Filaria of the human blood—*F. bancrofti*, which is propagated, like the malaria organism, through the medium of mosquitoes. [J. A. T.]

Filbert, the nut of *Corylus Avellana*, the cultivated hazel, a shrub or small tree which grows wild in the British Islands and other parts of Europe, especially in copses and hedgerows. Improved varieties of it are extensively cultivated in the south of Europe, and also in some parts of England, especially in Kent. The term cob-nut is applied to the variety with short-



Hazel (*Corylus Avellana*) with Flowers and Fruits

tailed husks, the filbert having longer tails. The trees will grow in any kind of soil, but are most fruitful in a light loam on a sandy subsoil. In this country they require a southern slope to give the best results. Plantations are made by setting young trees 10 ft. apart each way, and keeping them in order by judicious pruning. In Kent they are not allowed to exceed 6 ft. in height, the leader shoots being regularly cut back so as to induce the development of lateral growths, which are most fruitful. Generally they are trained to form short-stemmed standards, all suckers being carefully removed. Worn-out plants are often rejuvenated by cutting them down to within a foot or so of the ground, and selecting about half a dozen of the strongest shoots that spring up. The flowers are produced in two series; the male in the form of

catkins, which are developed very early in the year, and the female as little brush-tipped cones in the axils of the leafless shoots. To ensure a crop of nuts it is sometimes necessary to save the catkins, which develop sometimes in January, and to shake the pollen among the shoots when the female flowers are expanded, usually about March. The nuts are fit for gathering when the husks become brown. They should be dried, and packed in jars or casks with a sprinkling of salt to prevent mouldiness, keeping them in a cool dry place of uniform temperature. The nuts are sometimes attacked by a weevil (*Balaninus nucum*), which pierces the young shell and deposits its egg, from which a maggot develops and feeds upon the kernel. The most esteemed varieties are: Downton Large Cob, Frizzled Filbert, Pearson's Prolific, Webb's Prize, and White Filbert. [W. W.]

Filled Cheese.—'Filled cheese', so-named, was formerly made, in the United States of America, from skim milk with which melted margarine had been incorporated—hence the word 'filled'—shortly before rennet was added to coagulate the mass. There were temptations about filled cheese which to many men were irresistible, just as was the case with margarine as a substitute for butter. In their origin both were frauds, and intended to be frauds. Dairymen of the United States were tempted to make up their skim milk into cheese as the most remunerative outlet for it. They would take the cream out of their milk and replace it with margarine. And this sort of thing soon led on to margarine butter: skim milk would be utilized in giving to prepared animal fats in emulsion with it an adventitious flavour of butter. But filled cheese was more ambitious as a conception than margarine butter, because it aimed to put the casein of skim milk to a profitable use, whereas margarine butter could do no such thing with whatever casein was left behind in butter milk after churning. And the casein of skim milk was a considerable asset, whilst the casein of buttermilk was not.

Filled cheese, however, has had its day, and is now seldom heard of, and perhaps more seldom seen. It is, however, not yet extinct, as unwary buyers sometimes find out to their chagrin. That filled cheese was as an evil spirit in American dairying is well enough known in the great easterly section of the country which is chiefly devoted to the production of cattle and milk. It has been freely admitted that filled cheese has so seriously depreciated American cheese generally in the markets as to cause a loss greatly exceeding the sum total of whatever income has been derived from the sale of the sham product. [J. P. S.]

Filter, Filtration. See WATER SUPPLY.

Finance Act, 1894 (Woodlands).—Under this Act, which regulates the death duty payable on the capital value of an estate after the death of each tenant, laid down that the annual value of the woodlands was to be estimated, so far as the land itself is concerned, according to the actual value of the land itself in its natural and unimproved state, while the timber growing upon the land is to be subject to separate valuation. It therefore quite correctly recognizes the fact that the capital invested in woodlands consists partly in land and partly in the growing crop of timber or wood. To determine the value of the latter under the Succession Duty Act, the custom in England is to value all the timber and other wood, and then, treating this as the capital value, take 3 per cent as a fair annual return under good management. This return or average income is treated as an annuity, upon which succession duty has to be paid according to a sliding scale laid down in tables annexed to the Act and varying with the age of the incoming life-tenant. For example, if the new heir be forty years old and the woods bring in a clear income of £500 a year, then the capital value of the land plus the timber crops would in this particular case be considered to be £7437, in place of their actual value £500 ÷ 0·03 = £16,666. [J. N.]

Fine Earth.—This term is applied to that portion of the air-dried natural soil which passes a moderately fine sieve with meshes varying in diameter according to the views of the particular analyst. The majority of British workers favour a 3-mm. sieve. Hilgard, however, has used a sieve the mesh of which was as fine as 0·5 mm., while the American Bureau of Soils and the majority of Continental analysts employ one of 2 mm. diameter. Only the fine earth of a soil need be submitted to a detailed mechanical and chemical analysis; the larger material may be discarded as comparatively unimportant, since it has only a relatively small capacity for holding water, has a low capillary power, and contributes but a negligible proportion of the available plant-food materials of the soil. [T. H.]

Finger-and-Toe, or **Club-root.**—This widespread disease has several local names, *e.g.* Anbury and Grub. In the earlier accounts there was frequent confusion between this and other kinds of swellings on the tubers of turnips and swedes. The presence of various larvæ in the swellings of true 'finger-and-toe' did not simplify matters, but in 1878 Woronin clearly demonstrated that a slime fungus (*Plasmodiophora Brassicæ*) could infect the roots and produce this disease. The external symptoms are best seen on the roots as distinct from the tuber. On washing the roots free from soil, the 'fingers and toes' appear as thickened swellings or tumours suspended by a thin stalk which is the healthy part of the root (fig. 1). When the swellings are numerous, the root becomes a swollen, distorted mass. The tumours are generally confined to the roots and the lower root-end of the tuber, and in this way are distinct from several forms of insect gall frequent on the upper part of the tuber. On cutting across one of the 'finger-and-toe' swellings, the flesh of the root shows in places a marbled or mottled appearance distinct in tint from the healthy tissue. The diseased cells are larger than the healthy ones and occur in groups (fig. 2); sometimes when only one side of the root is swollen it can be seen that these nests of giant cells occur only in the swelling.

The life-history of *Plasmodiophora* may be stated briefly. A resting spore in the soil ger-

minates, its wall breaks in one place, the contents slip out as a tiny irregular body (myxamœba) with a hairlike flagellum (fig. 3). This myxamœba keeps constantly changing its form, and moves with the aid of the flagellum over short distances; in this way it may reach and become

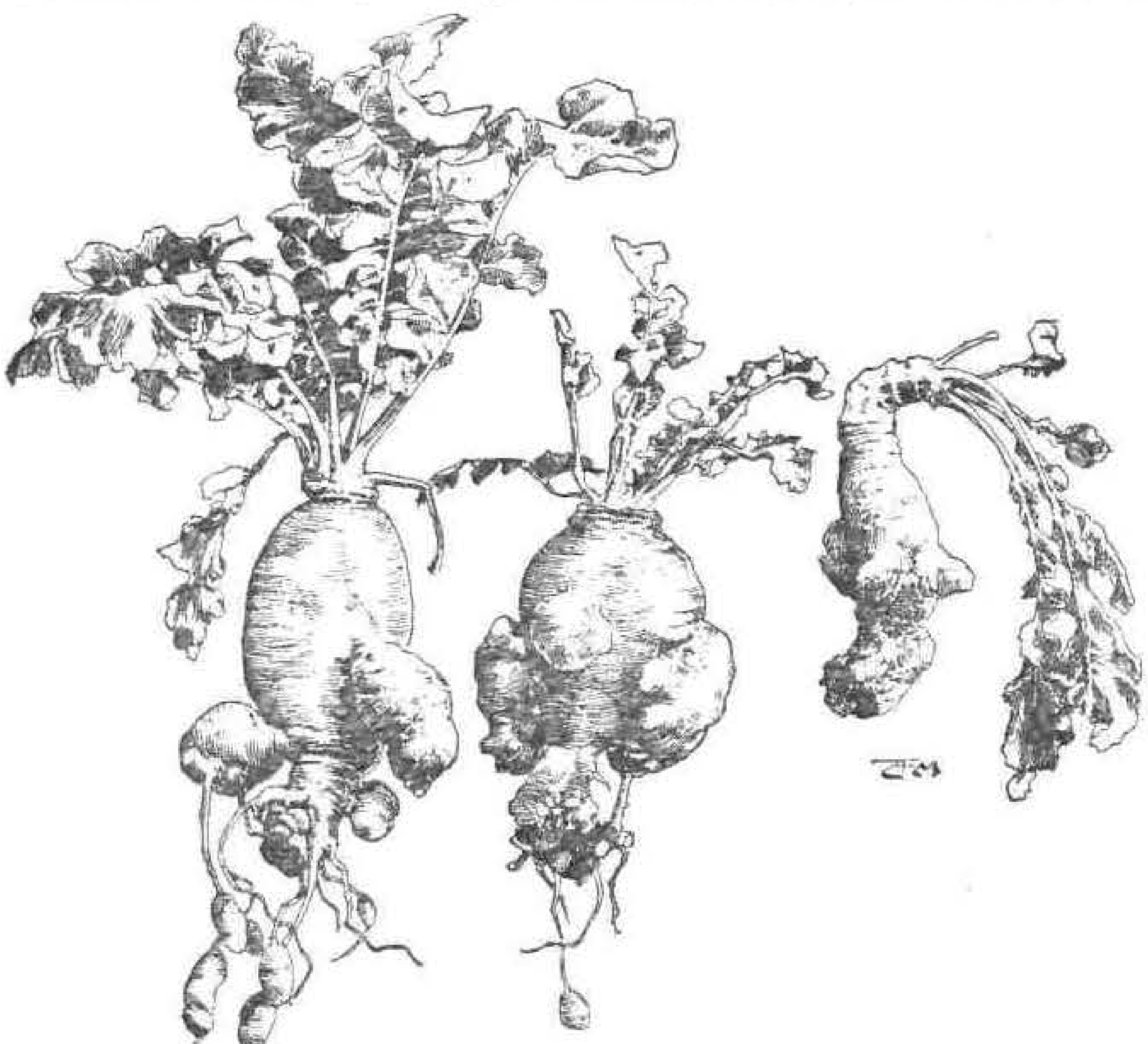


Fig. 1.—Finger-and-Toe Disease on Swedes. (From Tubeuf.)

attached to a root-hair of turnip or some other plant of the order Cruciferæ. The flagellum disappears, and the myxamœba becomes enclosed in the tissues of the root, where it grows and divides to form other myxamœbæ: at the same time it influences the cells of the host plant, so that they enlarge into giant cells and divide to

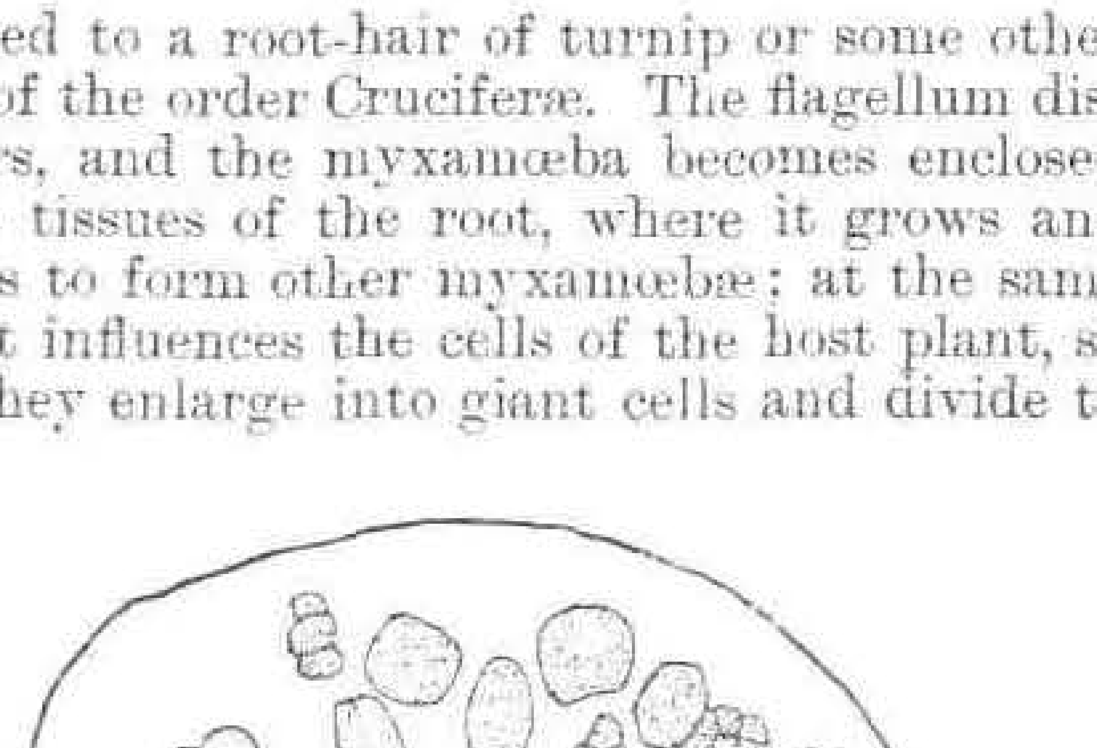


Fig. 2.—Section through Diseased Part of Root. (After Woronin.)

form nests. The affected portion of the root now enters on a period of rapid and abnormal thickening which results in the formation of a 'finger-and-toe' swelling. Up to this stage the slime fungus has encouraged the growth of the root in an exceptional degree, but sooner or later the tumour ceases to enlarge. Then the myxamœbæ form a slimy mass or plasmodium made up of many individuals; this plasmodium is a stage in the life-history of all slime fungi (Myxomycetes), hence the reason for placing *Plasmodiophora* in this group. The food material in the tumour now begins to be exhausted; as this proceeds, the plasmodium separates up into minute portions each of which becomes surrounded by a thick wall, and the resting-spore stage is reached. By the decay of the tumour the spores are liberated into the soil, where they can retain their vitality for several years. The fungus probably attacks all cruciferous crops; it has been observed in turnips, swedes, cabbage, cauliflower, kohlrabi, &c., also in rape, radish, wallflower, and several cruciferous weeds such as charlock. [W. G. S.]

PREVENTION OF FINGER-AND-TOE.—The amount of loss annually incurred by the farmers of Great Britain through the occurrence of this disease on the turnip and cabbage crops can hardly be overestimated. The extent to which the crop is injured varies from year to year according as the conditions are favourable or otherwise to the growth of the fungus, or to the resistant power of the turnip and cabbage plants, but there are few seasons in which the injury done to the crops is not serious, and many in which it is both extensive and disastrous. Of cure there is obviously none. Once the disease is established in the plants, nothing can be done to save them. Prevention, on the other hand, is perfectly possible, nor is it too much to say that by the intelligent action of farmers the almost entire extirpation of this very destructive disease might be quickly achieved. The means by which this end could be attained have been sufficiently shown in field experiments carried out in recent times by Jamieson in Aberdeenshire, Voelcker at Woburn, Somerville at Cockle Park, Campbell in Kirkcudbrightshire, and the present writer at the West of Scotland College Experiment Station. The necessary treatment resolves itself into:—

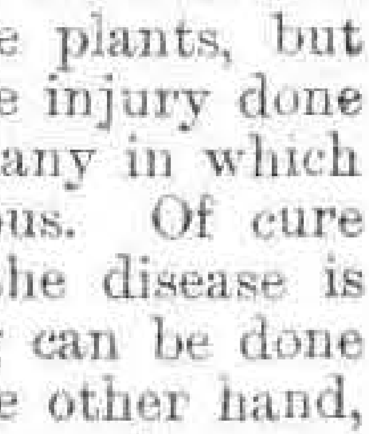


Fig. 3.—A, Resting Spores of *Plasmodiophora Brassicæ*; B, Spores ruptured, showing escape of Myxamœbæ C. (After Woronin.)

1. Isolation of the diseased roots and the infected soil, by which the spreading of the infection may be prevented.

2. The destruction of the disease spores in the infected soil.

3. The adoption of such methods of cultivation as will strengthen the plants sufficiently

to enable them to resist successfully the attack of the disease fungus.

The most important part of the treatment is that falling under the first of these divisions, and it is mainly because of the almost universal neglect of 'isolation' that 'finger-and-toe' forms at present one of the most formidable plant diseases with which the farmer has to contend. The essential condition to any successful prevention is to treat 'finger-and-toe' as an infectious disease which is as a rule conveyed to one crop by direct infection from another. It has been found in numerous experiments that the disease can be introduced with certainty and without difficulty into soil quite free from it, by the simple process of spreading on or mixing with the soil, cuttings of diseased roots, or sweepings of turnip sheds or pits in which diseased roots had been stored. But this infection does not spread except by means of parts of the diseased roots themselves, or by bits of the infected soil in which the roots have been grown. A diseased spot in a field does not extend itself over a greater area either through the atmosphere, or through the growth of the fungus extending itself into the adjacent uncontaminated soil. There is no rapid spreading nor conveyance of disease from plant to plant or from row to row till the outbreak first noticed in one spot of a field only is seen to cover the whole. Somerville had his infected rows of turnips growing side by side with the healthy rows, and the plants on the latter were quite unaffected. Campbell found that a sound crop of the same varieties of turnips and swedes grew round about and up to within 6 in. of the infected area, and it is quite common to see the disease existing in a destructive degree on one or more spots in a field of turnips, while the remainder of the crop is perfectly healthy. An infected spot contains, therefore, no danger for the remainder of the crop growing in the same season either in the same or in other fields. The danger is that the infection may be conveyed over the fields or to other parts of the farm to attack the crop of the next or succeeding years. From any single diseased spot, in fact, the disease may be spread in such a way as to contaminate not only the whole field but the whole farm, and under the common conditions of farm management that is what generally happens. In ordinary practice, diseased roots, if usable at all, are either consumed by sheep on the field or are conveyed to the farm steading to be fed to cattle. In the former case the infected soil from the diseased plot may be conveyed all over the field by the feet of the sheep, and in the latter case fragments of the diseased roots and bits of infected soil find their way from stalls and feeding troughs by way of the litter and excrement into the farmyard manure. The manure thus contaminated with disease spores is usually spread on the field in which the next turnip crop is to be grown, and the very means by which the farmer hopes to secure for himself a large crop of turnips forms too often the cause of its partial or complete destruction. More in this way than in any other is the 'finger-and-toe' disease spread and perpetuated on farms, and this too by farmers who may be incurring considerable expense in endeavouring by other methods to save their crops from its virulent attack.

In seeking to eradicate 'finger-and-toe' from a farm, the first step is to determine whether the disease exists in any part of the growing crop. Often it is found in head rigs or wet spots in fields in which the remainder of the crop may be quite healthy. Such spots should be marked off and separated absolutely from the remainder of the field. If it be desired to consume the roots in the field where they grow, sheep should be folded on the diseased area and should not be allowed to travel beyond it. If this be impracticable, all the affected turnips should be carted to a field of permanent pasture, or a field not to be ploughed for a number of years, and should be consumed there. If only a limited area of the turnip break be affected by the disease, this method should invariably be followed. Where a large area of the turnip crop is affected, it may, however, be necessary to convey the roots to the steading to be fed there. In this event, infection of the farmyard manure is quite unavoidable, and it should be subsequently treated as infected material. On no account should it be applied to a turnip or a cabbage crop, or the disease may be spread over a whole field. It may be put on the potato, mangel, or carrot crops, or it may be applied to a field in permanent pasture, while the turnip crop of the season should be grown with artificial manures alone. It is without doubt by the diseased roots themselves that 'finger-and-toe' is most generally communicated to a succeeding crop, and it is only by taking such precautions that the extension and perpetuation of the disease can be prevented. And the same precautions must be taken with the cleanings of turnip pits, turnip houses, and troughs in which turnips are fed to stock, which must also be treated as infected material. These should be kept carefully out of contact with the farmyard manure, and should be mixed for a time with fresh-burnt lime, after which the compost so produced may be applied to a field of permanent pasture.

The disease may, however, also be spread by bits of the infected soil itself adhering to the feet of horses and men, the wheels of carts, and the various implements of tillage. By these means the area occupied by an infected spot in a field may be gradually widened; but the risk of such extension is diminished by the fact that a turnip crop is not usually grown again in the same field in the immediately succeeding year. Neither is the conveyance of the disease to another field by this means a danger greatly to be feared. Nevertheless, as far as is practicable, the cultivation of the infected areas should be separately done, and horses and implements should have the infected soil scraped off before they are taken into other fields.

The infected soil of the disease spot must, however, also be dealt with, or it will remain a source of infection for a considerable period, and a turnip crop grown again on the same land in regular rotation may once more succumb to its attack.

It has been quite frequently observed by farmers that in a rotation in which turnips are grown every fifth year on the same land the crop is much more liable to be destroyed by 'finger-and-toe' than if the rotation be lengthened to six or seven years. A still more effective method of diminishing the risk is to alternate the green crop, and to grow potatoes or mangel in the one rotation on that part of the field on which turnips will be grown in the next. But this precaution may fail entirely in its effect if the land be not kept free during all the intervening period from other cruciferous plants, on which the 'finger-and-toe' fungus feeds as freely as on the turnip. For this reason the regular destruction of the Charlock (*Sinapis arvensis*) and the Runch (*Raphanus Raphanistrum*), weeds which occur in great abundance in our corn crops, forms an essential condition of the treatment required for the extirpation of the disease fungus. If no cruciferous plants be grown on the land for a series of years, the fungus will be killed out by the simple but effective process of starvation. Up till quite recent times the growth of the mustard weeds in corn crops formed an almost insuperable obstacle to the complete destruction of the 'finger-and-toe' fungus. But it has now been demonstrated that by spraying these weeds at an early stage of growth with a 3-per-cent solution of sulphate of copper applied at the rate of 40 gal. per acre, and by repeating the operation a second time ten days later to catch the plants of later germination, they can in most seasons be almost wholly destroyed. The complete disinfection of a soil containing the 'finger-and-toe' spores can therefore be very simply effected by the combined means of lengthening the rotation of crops and by destroying all cruciferous weeds that spring up during its course, and it only remains thereafter to avoid any reinfection of the soil through the farmyard manure or otherwise.

Various methods of treating the soil directly for the destruction of the disease spores have been tried, of which the most effective and reliable is that of the application of lime. The efficacy of lime is due to various causes. When first applied, quicklime kills the spores with which it comes into contact. It also produces changes in the soil which render it less favourable to the development of low fungoid growths. It improves the mechanical condition of the soil, neutralizes acidity, and produces other helpful chemical changes, while it is also known to strengthen the turnip plants and to stimulate them into a more vigorous growth. When it does not altogether prevent the appearance of the disease, lime frequently renders the attack comparatively innocuous.

The best form of lime to use is the ordinary burnt lime from the kilns, but conditions essential to its efficacy are that it should be applied in suitable quantity, in a finely divided form in which it can be well distributed through the soil, and so long before the turnip crop is grown that it may have had ample time to become thoroughly mixed with the soil and to produce its full effects on the disease fungus. In regard to quantity, 2 tons burnt lime per acre has generally been found sufficient, but larger dressings, up to 4 tons or more per acre, are still more successful. A smaller quantity finely divided and well distributed will prove as effective as a larger quantity not so well mixed with the soil. In the West of Scotland experiments it was found that burnt lime slaked in a large heap by pouring water over it, and applied to the soil soon after, while it was still in the form of a fine dry powder, was distinctly more effective than the same quantity of burnt lime allowed to slake itself slowly in heaps on the field, and applied after it had lost its fine powdery condition. Similar results were got by Somerville at Cockle Park, and by Voelcker at Woburn. Ground lime also proved an effective but more costly application. The application of lime in the drills in spring just before the sowing of the turnip crop has in no case proved nearly so successful as the application of the same quantity of lime in the previous autumn and winter. But a much earlier application is better still. A capital plan is to put a heavy dressing of lime on and around all affected spots in a field as soon as the diseased crop has been removed. This method has the advantage of bringing the lime at once into contact with the diseased parts of the roots and the fungoid spores in the surface soil. But where a whole field or a large area has to be treated, the best method of employing lime for this or any other purpose is to apply it on the top of the ploughed land in the winter following the removal of the turnip crop, and before the spring sowing of the seeds of the immediately succeeding crop. The harrowing-in of the seeds helps to distribute the lime more completely and leaves it well mixed with the surface soil. Failing this method, the lime may be applied on the grass land any winter before it is ploughed up, but the earlier the better. It is a favourite practice to apply lime on the stubble in the autumn before the turnip crop is to be grown, but it is much better to have had it applied on the grass one or more years earlier if the object desired be the prevention of 'finger-and-toe'.

Various other substances besides lime have been tried to check the ravages of the 'finger-and-toe' disease, but none of these has proved so effective as lime, or so generally suitable. Some of them have, however, been of service, and are capable of being used as adjuncts to the lime treatment. Gas lime produces some beneficial effect, but is not nearly so successful as burnt lime. In the Woburn and the West of Scotland experiments, sulphate of copper was found to assist in checking the disease. At the former station basic slag was also found to be helpful, and at the latter kainit was found to be of similar though less decided benefit. At Woburn, Voelcker also found that 4½ gal. carbolic acid added to 2 tons lime considerably increased the efficacy of the dressing, and this method of treatment seems deserving of further attention.

It is not, however, desirable, in combating the ravages of 'finger-and-toe', to place entire reliance on lime or other special dressings, to the exclusion of other means of assisting the turnip crop to resist the attack of the fungus. Other

conditions that affect the life and growth of the fungus and of the crop should also receive careful attention. It is well known that the disease shows itself most readily on wet and sodden parts of the field, where the land has become sour, as well as on parts where the mechanical condition of the soil has been rendered unfavourable through poaching, trampling, or imperfect tillage. Hence its frequent occurrence on the headlands of fields, which are specially liable to be poached by the trampling of horses and the turning of implements. Perhaps also their contiguity to the fences, about the sides and bottoms of which cruciferous weeds may be growing unchecked, may be a common source of contamination. The headlands of turnip fields must, therefore, always be regarded as probable sources of infection, and it would be an additional precaution to grow on them in the root-crop year a gramineous or a leguminous fodder crop such as rye or vetches, and to refrain from growing a turnip or other cruciferous crop on them at all.

The souring of the soil that occurs in wet and trampled spots in a field appears to be as favourable to the development of the 'finger-and-toe' fungus as it is prejudicial to the healthy growth of the turnip and other farm crops. It is therefore an important means of prevention in itself, and a valuable accessory to the preventive action of lime dressings, that land should be thoroughly drained, well and deeply cultivated, and worked only when dry; that any injurious pans should be broken up, and that the soil should be brought into such a mechanical condition as to admit the free movement through it of air and of water.

The final precautions that have to be taken are those that specially deal with the plant itself and the power it possesses of resisting the attacks of the destroying fungus. That the turnip plant does possess a distinct and by no means negligible power of resistance to the 'finger-and-toe' disease is proved by the fact that many more plants are usually attacked than are totally destroyed, while it is also well established that certain varieties of turnips possess a distinctly greater resistant power than others. Thus it is well known that white turnips succumb much more readily and completely to the disease than yellows, and yellows as a rule more readily than swedes, though exceptions to this latter rule are not unknown. There undoubtedly exists ground for hoping that varieties of turnips and swedes in other respects good may yet be found capable of resisting with success the attack of the 'finger-and-toe' fungus. Meantime it may be recommended that where the presence of the disease is suspected, hardy varieties of swedes should be selected for cultivation; for it has frequently been seen that swedes have been only slightly injured by the disease, when white and yellow turnips in the same field and growing under the same conditions have been almost completely destroyed. The crop may be grown on farmyard manure with artificials added, provided no diseased roots were consumed in making the manure; but if disease existed previously in the turnip crop, the farmyard manure should all be applied either to permanent pasture or to grass land not to be ploughed up for some years. The turnips can be grown quite successfully with artificial manures alone, but their proper selection is important. Jamieson has shown that the use of dissolved phosphates, in which sulphuric acid has been used to dissolve the phosphate, renders the plant distinctly more liable to fall a prey to the 'finger-and-toe' disease. The soluble phosphate causes an unusually rapid growth of the young turnip plants, and this is accompanied by a weakness that renders the plant less able to resist the fungoid attack. The acidity of the manure and the supply of sulphur given in it are also believed by Jamieson to favour the development of the 'finger-and-toe' fungus. The most suitable phosphatic manure to use when 'finger-and-toe' is suspected is basic slag, which causes a steadier and somewhat less rapid growth of the turnip plants, while its alkaline action on the soil is unfavourable to the fungus. The addition of kainit to supply potash to the growing plants is likewise helpful to the turnip and hurtful to the fungus. Nitrogenous manures, which have a somewhat forcing and weakening effect on the plants, should be given in moderate quantity only, but should not be altogether withheld. To give incomplete or insufficient manures is to starve the plants, to reduce their vigour, and to render them more easily liable to be destroyed by the attacking fungus. The unmanured plots in all experiments have been the most readily and completely destroyed by the disease.

A suitable manuring for Scotland, Ireland, and the north of England would be 6 cwt. basic slag, 4 cwt. kainit, and 1 cwt. nitrate of soda per acre. Smaller quantities of slag and kainit would be required in the south of England. Such a manuring should as a rule produce as good a crop as could be grown on farmyard manure. [R. P. W.]

Finish (Ploughing).—Finishes, or the methods of ploughing the last few furrows on a 'land' or 'stetch', take several forms. The finish serves two purposes, for it ensures the turning over of every portion of the land, and provides a surface watercourse on heavy land. Previously to the introduction of the reaping machine, a deep mould-furrow finish in which the last furrow was ploughed deeper than the other furrows was most used; now the last furrow is very little deeper than the others. When the mould furrow is not ploughed, it is called an open-furrow finish, leaving the width of two furrows bare. When an already ploughed furrow is turned back to fill in the open space, it is called a furrow-back finish. See also PLOUGHING. [W. J. M.]

Fir, a name for the Scots Pine, is now indiscriminately used as the name of many trees belonging to the Abietineæ tribe of the Coniferæ family (see CONIFERS). The only tree of this kind indigenous to Britain is the Scots Pine or Common Fir (*Pinus sylvestris*), which grew in southern England during past geological periods, though only indigenous to Scotland and Ireland during historic times. It was introduced from Scotland into the New Forest (Hants) in 1766, and has since then been largely

cultivated throughout England and Wales. The popular use of the term 'Fir' is confusing, because several well-defined genera are thus included. See arts. on DOUGLAS FIR, LARCH, PINE, SILVER FIR, and SPRUCE. [J. N.]

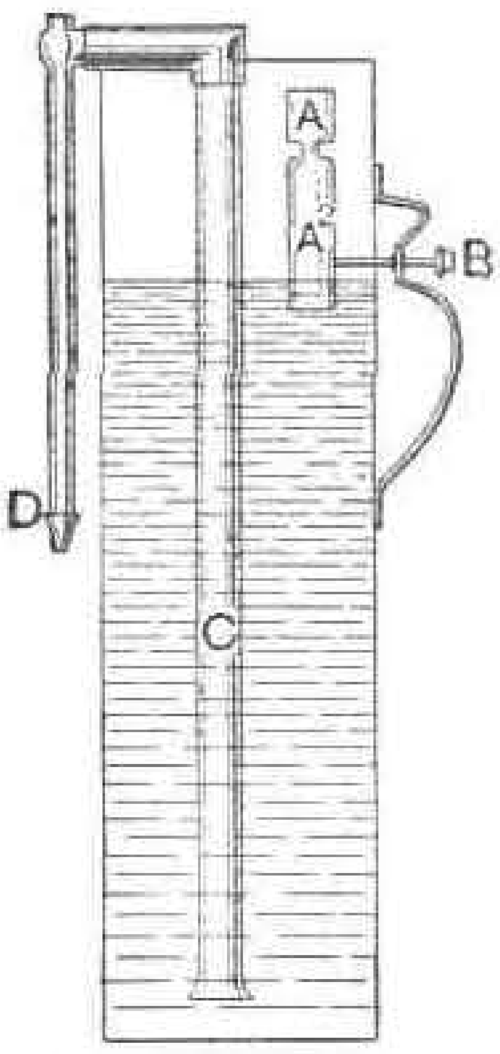
Fir. — Parasitic Fungi. — See arts. on PARASITIC FUNGI OF DOUGLAS FIR, LARCH, PINE, SILVER FIR, SPRUCE, &c.

Fire.—Fires are not uncommon on farms, as there is a considerable quantity of inflammable material produced on them, and it is often exposed to risks from various sources. Incendiary fires are comparatively rare, and fire insurance societies have for many years ceased to attach the metal tablets bearing their seal to insured buildings, which a century ago, when incendiarism took an organized form, were regarded as desirable to indicate that the individual would not suffer, because he was insured against fire. Many farm fires have been caused by steam engines, especially when used for threshing, when there is much inflammable material in proximity. Sparks from the chimney or from the firebox are usually the direct agents; few chimneys are adequately protected by spark catchers or dampers, and when in darkness one sees the number of sparks emitted it seems extraordinary that fires are not more frequent. When the engine stands near to thatched roofs in dry weather, wetted tarpaulins should be placed on them on the windward side. The ashpan should be kept well saturated, and the driver should not leave his engine until he has raked out all firing and well drowned it in water. Fires have occurred through leaving wood to dry in the firebox or ashpan which has become ignited, and sparks from which have been blown into dangerous places. This practice should not be allowed. Fires have also occurred from bearings being allowed to become overheated. Guns fired into stacks when rat-catching have caused many fires, especially where paper has been used as wads; they should not be fired towards a stack within twenty yards. Tobacco smoking is a frequent cause of farm fires, and should not be permitted where there is a possibility of danger. Railway locomotives cause many farm fires, and in dry seasons fields of ripened corn are burned (see next art.). When a field fire breaks out, ploughs should be hastily brought up to plough a track across which the fire cannot pass, and the fire be beaten back with brushwood. Hedgerows are a source of danger on these occasions, and in dangerous positions may require to be pulled up or cut down. Large quantities of cake, especially cotton cake, are liable to generate sufficient heat to cause natural combustion. Haystacks made from insufficiently dried hay frequently generate fire, and a watch should be kept over heating stacks that the heat does not reach danger point. If left too long, and endeavour is made to take down the stack, the air is liable to make it break into flames. Fires caused by self-combustion are not covered by insurance. [W. J. M.]

Fire. — Railway Fires Act. — Railway companies acting under the statutory authority and within the scope of that authority are not liable to make reparation for damage caused in the conduct of their business unless negligence against them be proved. 'The legislature, by authorizing the use of steam power without limitations as to the power of the engine or the speed of locomotion, has impliedly indemnified the Company against the consequence of the use of such engines, provided they are of the best construction and the proper safeguards are used for minimizing the risk of fire damage.' Consequently, where the company uses the best practicable means according to the existing state of knowledge, it is very difficult to prove negligence. In order to secure compensation for damage by fire caused by sparks or cinders from railway engines, the Railway Fires Act of 1905 was passed, which, however, did not take effect until 1st January, 1908. The following are the provisions of the Act: (1) Where damage is caused to agricultural lands or crops by fire arising from sparks or cinders from an engine, the fact that the engine was used under statutory powers shall not affect liability. If the damage was caused by an engine belonging to one company on a line worked by another company, either company shall be liable to an action, but if the action is brought against the company working the railway they shall be entitled to be indemnified in respect of their liability by the company by whom the engine was used. The section shall not apply in case of an action for damages unless the claim does not exceed £100. (2) The railway company has power to enter on land and do all things reasonably necessary for the purpose of extinguishing or arresting the spread of a fire so caused. For the purpose of preventing or diminishing the risk of fire in a plantation, wood, or orchard, the company may enter upon any part of the plantation, wood, or orchard, or on any adjoining land, and cut down the undergrowth, but they shall not without the consent of the owner cut down or injure any trees, bushes, or shrubs. Compensation shall be paid by the company for the exercise of these powers, including compensation in respect of loss of amenity. The third section enacts that no action will lie unless notice of the claim and particulars of damage in writing shall have been sent to the company within seven days of the occurrence of the damage as regards the notice of the claim, and within fourteen days as regards the particulars of the damage. Section 4 enacts that agricultural land includes arable and meadow land and ground used for pastoral purposes, or for market or nursery gardens and plantations and woods and orchards, and also includes any fences on such lands, but does not include any moorland or building. The expression 'agricultural crops' includes any crops on agricultural land whether growing or severed, which are not led or stacked. The expression 'railway' includes any light railway and any tramway worked by steam power. [D. B.]

Fire Extinguishers. — Apart from fire engines, which are rarely kept on a farm, there are many contrivances for checking the progress of freshly ignited fires by applying a gas or spray inimical to combustion. Several of these noxious substances are employed, but the most

common is carbonic acid. The vessels or instruments vary in details of construction, and are generally of glass or metal—glass being most commonly used where it is to be used as a missile, and metal where it takes a portable form and where the charge can be directed. The object is to bring into contact two or more substances, previously kept apart within the instrument, to produce an active chemical combination to generate the necessary deterrent gases. A bottle hurled and broken will effect this, but in other types sometimes the inversion of the instrument will cause mixing to take place, while in others mechanical means are provided to cause breaking of the bottle containing the acid. In the illustration given, a method of mixing acid contained in a glass bottle with an alkali is shown—A and A² being two divisions of a bottle with a narrow neck between them; B is a plunger which on being pressed breaks the bottle, the gas generated passing up an inner tube C to the outlet pipe with a nozzle at the end. In those kinds where mixture is made by inversion, it is obviously necessary not to invert the instrument until it is required for its proper purpose. [W. J. M.]



Fire Extinguisher

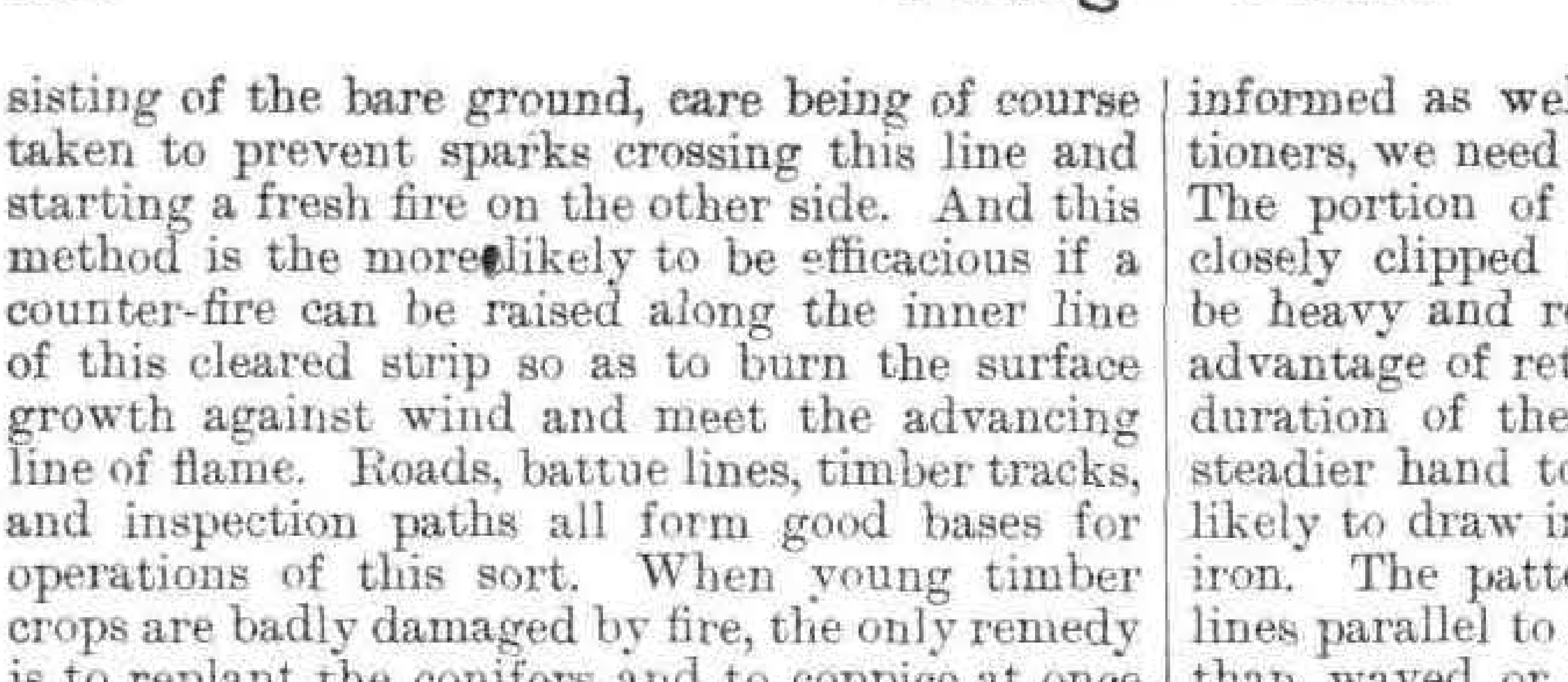
Fire Fanging.—The common cause of fire fanging, or firing of dung, is overheating due to the open, porous condition of the manure heap, which allows the fermentation to proceed rapidly and results in a loss of fertilizing material. This can best be avoided by keeping the heap constantly compressed and saturated, a condition of things secured by the constant treading of animals in yards and covered courts; by wheeling each barrowload over what was there before, or by loading the manure heap with soil or decaying turf. Under these circumstances the air is excluded and rapid decomposition arrested.

Fire Insurance. See INSURANCE.

Fires in Woodlands are chiefly occasioned by negligence or else by deliberate incendiarism, though they may also arise by sparks from steam engines (railway and road-traction). In Britain such fires usually only assume the form of ground fires, beginning among dry grass or dead leaves, and in passing through young woods or plantations they may kill the crops outright, or scorch and seriously injure young pole woods, although in thick-barked older crops (like Oak and Pine) the damage is seldom serious. And, of course, resinous coniferous plantations suffer more than broad-leaved crops, because when injured badly they cannot, like the latter, be cut back flush with the ground and thus made to spring afresh from the stool. In warm and dry countries, however, ground fires sometimes (and especially in coniferous woods) develop into conflagrations through the flames gaining possession of the crowns of the trees, when the wind carries the fire forward and completely kills the foliage and young branches. In Britain the greatest risk of damage from fire is on poor sandy and heathery stretches planted with Pine and Larch; for there the soil and the surface growth become dry like tinder, while the crop is resinous and highly inflammable. Fires are mostly to be feared in April, when east winds have dried the surface growth, and in August at the height of the summer drought; and, of course, long-continued drought increases the risk of fire breaking out, while wind increases the danger of its spreading quickly. Owners of traction engines going along roads have long been held responsible for damage caused by sparks to field and woodland crops; but it was not until the Railway Fires Act, 1905, came into operation on 1st January, 1908, that any compensation could be claimed 'for damage by fires caused by sparks or cinders from railway engines'; and even under this the claim for compensation for damage done is limited to £100 in each case—although as regards large conifer plantations the injury may easily amount to a very much larger sum. The best way of preventing fires arising from negligence is the proper supervision of all workmen and others employed in woods or their immediate neighbourhood, while the general public ought not to strike matches or throw away lighted cigar ends, or indeed make use of fire in any shape at all in woodlands. Where railways pass through woods or plantations the best way of preventing fires in coniferous crops is to clear away all surface growth and dead foliage along strips about 20 yd. wide on each side of the railway line, and to plant these with broad-leaved trees (especially Birch and Robinia in poor Pine tracts) whose green leaves may intercept the live sparks and cinders thrown out by the engines passing. But to be effective these bare strips must be kept free from dead foliage, &c., by frequent sweeping with brooms and by constant supervision. Unless this can be arranged, the best chance of protection lies in underplanting the Birch or Robinia with Sweet Chestnut or whatever other broad-leaved tree will coppice freely and grow thickly under this light and sparse overwood. For the extinction of fires that break out, as many men as possible should be at once collected and provided with green boughs, besoms, spades, hoes, and axes. If this aid is quick, a small fire may often easily be put out before it has had time to run far through the wood or plantation. But if once the fire has got a firm footing, it creates a current of air for itself and is more difficult to extinguish. It is then best to attack it from the flanks, and work from there towards the middle of the advancing line of fire, unless the air is sufficiently windstill to admit of the running edge of flame being attacked at various points simultaneously, which is impracticable on account of the acrid smoke when the fire is being impelled onwards by wind. If the fire has thoroughly established itself before men can be collected, it is usually best to push on ahead of the fire and clear away the surface growth so as to form a barrier con-

sisting of the bare ground, care being of course taken to prevent sparks crossing this line and starting a fresh fire on the other side. And this method is the more likely to be efficacious if a counter-fire can be raised along the inner line of this cleared strip so as to burn the surface growth against wind and meet the advancing line of flame. Roads, battue lines, timber tracks, and inspection paths all form good bases for operations of this sort. When young timber crops are badly damaged by fire, the only remedy is to replant the conifers and to coppice at once the broad-leaved kinds, which will then usually retain sufficient vitality in their root-systems to enable them to shoot from the stool, though perhaps only feebly at first. Among the broad-leaved trees, Beech is the one least hardy against damage by fire. When any fire has occurred in woodlands, the forester should pay particular attention to note the presence of noxious insects, because the reduced vitality and the physiological disturbance thus caused are very likely to occasion insect attacks. [J. N.]

Firing.—Firing is always understood in veterinary practice to refer to the use of the hot



Firing Irons

iron upon the limbs in connection with the various forms of lameness, although it might with equal propriety be applied to the severance of the spermatic cord, or the destruction of morbid growths on any part of the body by the actual cautery. To the humane man there is something repellent in searing the living tissues of an animal; but the results justify the use of the hot iron, and the more general adoption of chloroform by veterinary surgeons reduces the pain to a minimum, the animal probably suffering no more after-effects than from an ordinary blister. 'Since', as Professor Axe has said, 'the necessity of firing is admitted by the best informed as well as the most humane practitioners, we need not stay to defend the practice.' The portion of a limb to be fired should be closely clipped and washed; the irons should be heavy and red-hot, on account both of the advantage of retaining heat and shortening the duration of the operation, and of affording a steadier hand to the surgeon, who will be less likely to draw irregular lines than with a light iron. The pattern is immaterial, but straight lines parallel to each other are less of an eyesore than waved or varied marks. Diamonds and lozenges are rather fanciful displays of skill, and offer more opportunities of friction and blemish. Many practitioners fire horses standing, if the extent of skin to be covered is not great; and quite a large number of horses submit to the performance without the use of cocaine, which ought to be employed either as a 4- or 5-per-cent solution injected under the skin of the part, or painted over the surface, when double strength is advised. It is usual to cast horses in hobbles, then put them under the influence of chloroform, and complete the operation without struggling or consciousness of pain. The patient is afterwards secured by double halters to the pillar reins, to prevent him from injuring the suffering member, until it is considered safe to release him. A long rest, preferably in a loose box or at grass, is prescribed for the subjects of firing. The binding down of the skin and the effects of a permanent bandage can in no other way be secured, in addition to which the pressure promotes the absorption of bony and other deposits. [H. L.]

Firkin generally denotes a small cask for holding liquids such as ale, or solids such as fish or butter. Though now of no fixed capacity, the firkin used to measure a quarter of a barrel or 9 gal., or when filled with butter to weigh 56 lb.

Firlot, an old Scotch dry measure of capacity containing a quarter of a boll. The firlot varied in different localities and with different kinds of grain. The wheat firlot measured 2214 cubic inches, and the barley firlot 3232 cubic inches.